3

# FILARIASIS IN SABAH

by

R. BARCLAY

M.D. University of Edinburgh 1969

CONTENTS

# PREFACE

While serving as a Medical Officer in the State Medical Service of Sabah in 1963 (at that time the Colony of British North Borneo), the writer became interested in filariasis by finding two patients suffering from tropical pulmonary eosinophilia. In view of the possible association between this condition and filarial infection, small surveys of filariasis were carried out in the Brunei Bay area, and infections due to Brugia malayi were found.

In 1966 the writer was employed by the Ministry of Overseas Development, London, to carry out a survey of filariasis in Sabah, under Colombo Plan arrangements. The findings of the survey form the bulk of this thesis.

The work and the composition of the thesis are my own.

# SUMMARY

1. Filariasis in Malaya, Singapore, the Philippines, Indonesian Borneo and Sarawak is reviewed briefly, and previous knowledge of filariasis in Sabah in more detail.

2. The results of a survey of filariasis in Sabah are presented.

3. Infections due to the sub-periodic form of Brugia malayi were found to be endemic in freshwater swamp areas in the south west and the north east. Wuchereria bancrofti infections were found to be endemic in hilly areas of primary forest in the south west, north east and upper Kinabatangan regions, the areas of maximum rainfall in the country. Filariasis was not found in urban areas.

4. Most infections seemed to be asymptomatic.

In areas where B.malayi was endemic the commonest clinical manifestation seen was elephantiasis of mild degree affecting the leg below the knee. In areas where W.bancrofti was endemic the commonest lesion seen was hydrocele.

A higher proportion of those infected with W.bancrofti developed clinical lesions than those infected with B.malayi.

5. Clinical disease rates were greater in males than in females, and increased with advancing age.

In males infected with B.malayi the prevalence of microfilaraemia increased till middle age, and thereafter declined: in females the prevalence increased till early adult life, then decreased till middle age, and increased thereafter. Microfilaria

densities were similarly affected by age and sex, and the changes in density preceded the changes in the prevalence of microfilaraemia.

6. Treatment with diethylcarbamazine eliminated the microfilariae in most of those treated. There was a high incidence of febrile side reactions to treatment in those infected with B.malayi, and a rather lower incidence in those infected with W.bancrofti.

7. Infective larvae of Brugia species were found in Mansonia bonneae/dives and these mosquitoes are thought to be the vectors of B.malayi.

8. Small numbers of animals and birds were examined. Microfilariae of Brugia species, thought to be B.pahangi, were found in cats. Dogs were found to be infected with Dirofilaria species, and unidentified microfilariae were found in other animals and in birds.

9. The fluorescent antibody test was found to be positive in those with elephantiasis, and negative in symptomless microfilaria carriers.

10. These findings are compared with the findings in neighbouring countries.

# 1. INTRODUCTION

## 1.1. Filariasis in Malaya, Singapore, the Philippines, Indonesian Borneo and Sarawak.

Filariasis due to Brugia malayi in Malaya has been reviewed by Wilson (1961). In that country both Wuchereria bancrofti and B.malayi occur.

Two forms of B.malayi have been distinguished in man in Malaya (Wilson et al, 1958). In the periodic form microfilarial periodicity is markedly nocturnal; in the sub-periodic form microfilariae tend to be present in the blood at all times, with a less marked nocturnal rise in count. The two forms of B.malayi occur in different topographical areas. The periodic form is found in open swamp country with pools of floating water plants, such as water hyacinth, which are the breeding sites of the vectors; the sub-periodic form is found in fresh water swamp forest country, where the vectors are present in large numbers.

Edeson and Wilson (1964) list the vectors as follows :

| Periodic B.malayi | | Sub-periodic B.malayi | |
|---|---|---|---|
| Anopheles campestris | Malaya | Mansonia annulata | Malaya |
| A.lesteri | China | M.bonneae | Malaya |
| A.sinensis | China | M.dives | Malaya |
| M.annulifera, M.indiana | Oriental region | M.uniformis | Malaya |

Wharton, Laing and Cheong (1963) have reported a focus of periodic B.malayi transmitted by M.dives and A.donaldi.

The biology of Mansonia mosquitoes in relation to the transmission of filariasis has been studied in detail by Wharton (1962).

Natural infections with sub-periodic B.malayi have been found in a wide range of wild and domestic animals (Laing, Edeson and Wharton, 1960) and human infections can be transmitted to animals (Edeson and Wharton, 1958; Laing et al, 1961; Edeson et al, 1962). A closely related species, B.pahangi, also occurs in wild and domestic animals, and though natural human infections with this parasite have not been reported, it has been transmitted experimentally to man. (Edeson et al, 1960).

The periodic form of B.malayi is rarely found in animals, and Wilson (1961) is of the opinion that in areas where this form of B.malayi is found, animal reservoirs of infection are unlikely to be of epidemiological importance.

The clinical features of filariasis due to B.malayi have been described in detail by Turner (1959). The early manifestations are episodes of adeno-lymphangitis, usually accompanied by fever. Later these episodes are accompanied by transient swelling of the affected limb; at a later stage these swellings become permanent elephantiasis. Elephantiasis of the arm or scrotum is rare, and commonly the elephantiasis affects the legs below the knee.

Recently foci of infection with sub-periodic B.malayi have been reported from an area of swamp forest in Palawan, north of Borneo, where the vector is M.bonneae (Rozeboom and Cabrera, 1965; Cabrera and Tamondong, 1966 ) and from Sulu (Cabrera, 1968). In Palawan cats and dogs were found to be infected with Brugia species, either B.malayi or B.pahangi.

Urban foci of infection with W.bancrofti have been found in Penang in Malaya (Wilson, 1954) and in Singapore (Danaraj et al, 1958) where the vector is Culex pipiens fatigans. More recently endemic foci of infection with W.bancrofti have

been found in rural areas of Malaya, where the vectors have been shown to be Anopheles whartoni, A.letifer and A.maculatus (Reid and Edeson, 1957; Wharton et al 1963, Reid, 1963; Cheong and Abu Hassan, 1965). These rural strains of W.bancrofti do not develop readily in C.p.fatigans.

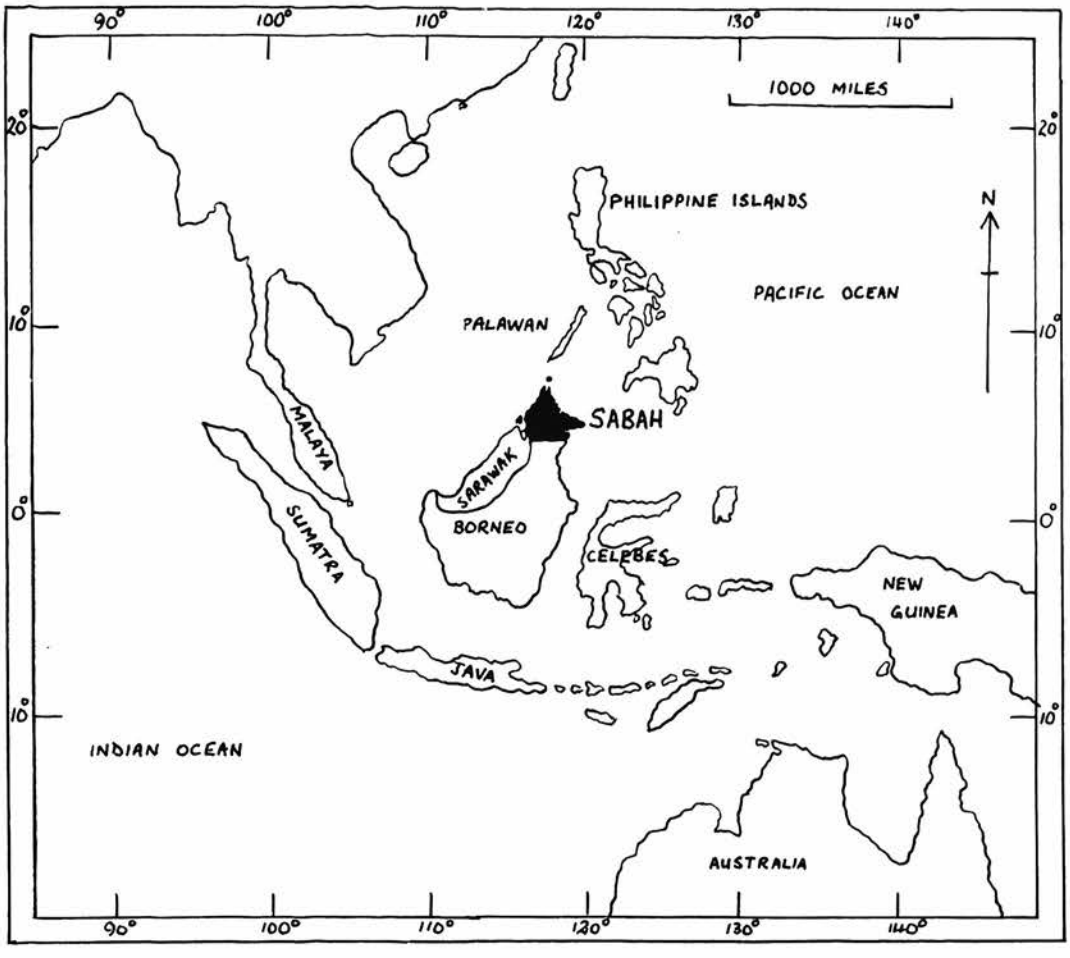
In the Philippines W.bancrofti infections are widespread. In areas where abaca is grown the vector is Aedes (Finlaya) poicilius (Cabrera and Tubangui, 1951; Estrada and Basio, 1965), and in other areas A.minimus flavirostris (Rozeboom and Cabrera, 1965; Cabrera and Tamondong, 1966; Cabrera, 1968). It is nocturnally periodic (Cabrera and Rozeboom, 1965).

The commonest clinical manifestation of the disease in these areas is scrotal elephantiasis, and elephantiasis of the breast and legs, and chyluria have also been reported (Estrado and Basio, 1965).

Reports on filariasis from other parts of Borneo are scanty. In Indonesian Borneo, infections with B.malayi and W.bancrofti have been reported (Brug, 1931; Kariadi, 1938; Klokke, 1961). In Sarawak and Brunei, Zuluetta (1957) reported that B.malayi infections were common in the flat coastal lands, and that W.bancrofti infections occurred in the interior of Sarawak.

## 1.2. Description of Sabah

The State of Sabah, previously British North Borneo, forms the northern tip of the island of Borneo, together with a few off-shore islands. The land area is 29,388 square miles - about 10% of the whole island. It lies between $4^{\circ}$ 15' and $7^{0}$ 40' latitude north and $115^{\circ}$ and $119^{\circ}$ 30' east.



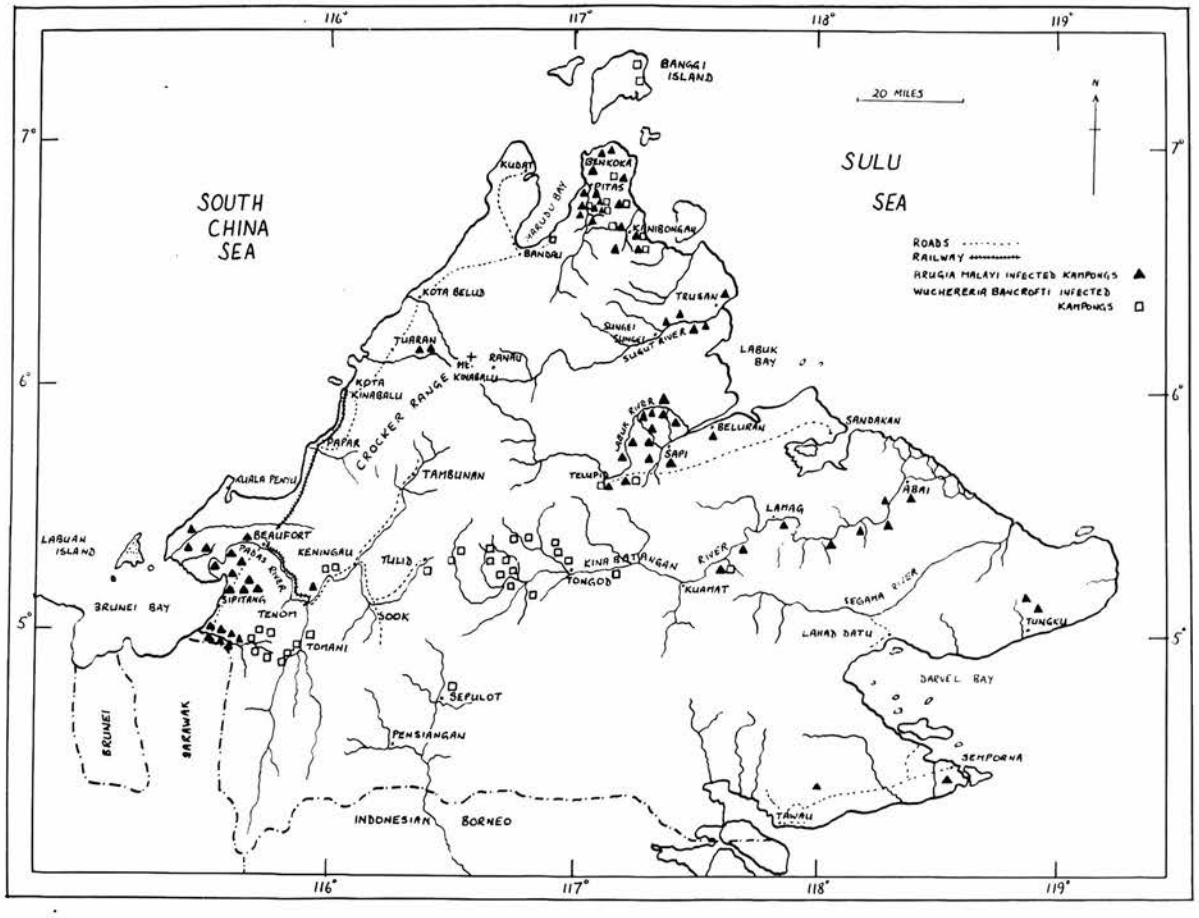

Map 1. Showing the geographical position of Sabah.

It is roughly triangular in shape with maximum distances of 328 miles east-west and 180 miles north-south.

Much of the country consists of jungle covered mountains, the highest peak being Mount Kinabalu which is 13,455 feet above sea level. The mountainous interior is drained by four main rivers - the Padas river flowing to the west, and the Labuk, Kinabatangan and Segama rivers to the east. In addition there are numerous smaller rivers which either flow direct to the sea or connect with one or other of the four main

river systems. There is an alluvial coastal strip of variable width.

For the greater part the interior is sparsely populated, the inhabitants engaging in shifting cultivation and hunting. There are however four unconnected plains extending in a chain in a south-westerly direction from the foot of M.Kinabalu. Of these plains, three - Ranau, Tambunan and Keningau - are cultivated and therefore more densely populated than the rest of the interior. The fourth, Sook, is infertile and sparsely popula ted.




Map 2. State of Sabah

On the east coast the alluvial strip is broader, but is mainly covered with swamp forest, and here timber extraction provides much of the wealth of the country. In the wake of the timber extraction large settled areas of cultivation have sprung up around Sandakan, Lahad Datu, Semporna and Tawau.

The two main towns, Kota Kinabalu, the State capital, on the west coast, and Sandakan on the east coast between them have a population of about 70,000.

The climate is equatorial with mean temperatures of about 90°F varying little throughout the year. Rainfall varies between 60 and 160 inches a year, the driest areas being in the interior, and the wettest the coastal areas to the south-west and north-east. There are two monsoons a year. The north-east monsoon, lasting from December to February, brings heavy rain and strong winds to the north-east part of the country. The south-west monsoon, gentler than the north-east, lasts from June to August, and brings much rain to the south-west area and the southern half of the west coast. Any climatic description of Sabah can only be very general, for the mountainous nature of the country leads to great variations from one valley to another and from one stretch of coast to another.

In 1967 the population was about 547,000 (based on the official Population Census of 1960 - population 454,421 - with an annual increase of 2.9%), and consists of many ethnic groups. There is a large Chinese community engaged mainly in trading. Of the indigenous groups, the Kadazans are the most numerous and are found in the interior north of Keningau and in the settled areas of the coast. The Muruts, the least developed group, are found in the interior south of Keningau. Round the coast are numerous Muslim communities of Malay stock - Brunei Malays, Bisayas, Kedayans, Bajaus, Illanuns,

Suluks, Tidong and others. In addition, especially on the east coast, there are many immigrants - Bugis from the Celebes, Timorese, Javanese and some Philippinos. Some of these people have lived in Sabah for generations, others were brought in before the Second World War to work on the various estates, others during the war by the Japanese as forced labour, and many more have arrived since in search of employment.

The various ethnic groups adhere to their own customs, culture and languages, more especially in the interior and the more remote parts of the east coast where Western influence has made little impact. In most places the men at least speak a crude form of Malay, which forms the lingua franca of the country.

Outside of the towns and townships the people live in kampongs, a term which requires some explanation. In a very few instances a kampong is a compact group of dwellings, but the majority of kampongs are either groups of houses spread out for a mile or two along a river bank, or wide areas covering up to several square miles with isolated houses scattered about throughout the area. The Muruts and the Kadazans of the north-east traditionally live in long-houses: long structures with a communal central area and individual rooms leading off a central passage, the whole community dwelling under the one roof. With the abandonment of headhunting and the associated intertribal strife the defensive value of these structures has diminished, and they are slowly giving way to kampongs of the type more usual throughout the rest of the country. Each kampong has its own Ketua Kampong, or village head man, and each area has its own Native Chief. If in any area there is more than one racial group present in numbers, each group has a separate Native Chief. These men have considerable authority in their areas and have judicial powers in matters affecting native custom.

Communications are poorly developed in Sabah. A single-track railway joins Kota Kinabalu with Tenom in the interior. On the west coast there is an adequate system of roads, though many are unsealed and suitable only for four-wheel drive vehicles. There are a few roads and bridal tracks in the interior, but much of the population is accessible only on foot or by river. On the east coast, Tawau and Semporna are joined by road, and there are some roads round Lahad Datu and Sandakan. From Sandakan an earth road has reached 90 miles westwards into the interior: this will eventually link Sandakan with Kota Kinabalu.

## 1.3. Previous knowledge of filariasis in Sabah.

Although filariasis has been known to occur in Sabah for a number of years, Shircore (1937) reported not seeing filariasis during an investigation of native health in the country. Clarke (1951), while investigating the health of the Muruts in the interior, saw two cases of elephantiasis. Regester (1956) stated that microfilariae of W.bancrofti were found in night blood films of 3-10% of those examined from several parts of the interior. Filarial infections have also been reported from the neighbourhood of Tenom, Keningau, Kudat, Banggi Island and the mouth of the Kinabatangan river. Infections due to B.malayi and W.bancrofti have been reported in immigrant workers on the east coast (information from the records of the Government Medical Service, Sabah). Infections due to sub-periodic B.malayi were found in the Brunei Bay area in 1963/64 (Barclay, 1965).

## 1.4. Reasons for conducting the survey

In 1966 a request was made by the Sabah Government to the Ministry of Overseas Development, London, for assistance in carrying out a survey of filariasis in the State, to establish the distribution and prevalence of filariasis, and to assess its importance as a public health problem. The writer was appointed to carry out this survey, which was done between August 1966 and August 1968.

## 1.5. Survey procedure

The survey team consisted of the writer, one trainee health inspector, one assistant malaria technician, two labourers, and a microscopist. None of the local staff had any previous experience of this type of work, and they were trained by the writer in the course of the survey.

In each area visited enquiries were made of Medical Department staff, Native Chiefs and Ketua Kampong about the presence or absence of symptoms which could be attributed to filariasis: swellings of the limbs or scrotum, or episodes of fever accompanied by such swellings or lymphangitis or enlarged lymph glands. The nature and purpose of the investigation was explained.

Individual kampongs were then visited and arrangements made with the Ketua Kampong for as many people as were prepared to co-operate to assemble at some convenient place in the evening. Blood films were made from these people between the hours of 19.00 and 23.00, each film containing 20 c.mm. of blood. The films were air dried overnight and either stained with Giemsa stain diluted 1 in 50 with distilled water buffered to pH 7.2 the following morning, or dehaemoglobinised in distilled water and stained by the same method at a later more convenient time.

While the blood films were being made the people were asked about symptoms attributable to filariasis, and all those admitting to such symptoms were examined. The limbs of all those who had blood films taken were examined for signs of elephantiasis.

The blood films were examined by the microscopist. All films reported to contain microfilariae were examined by the writer, together with about 10% of those reported to be negative.

## 2. Distribution and prevalence.

The findings of the survey are described area by area.

### 2.1. Brunei Bay area: (Map 3 )

Estimated population 32,000

Number examined* 3,227 (10.1%)

This area is mainly low lying swampy country forming the coastal fringe between the Crocker Range and the sea. There is much swamp forest in the area. Rubber is cultivated on the small hills rising above the swamp. The inhabitants are mainly Malays of Brunei origin.

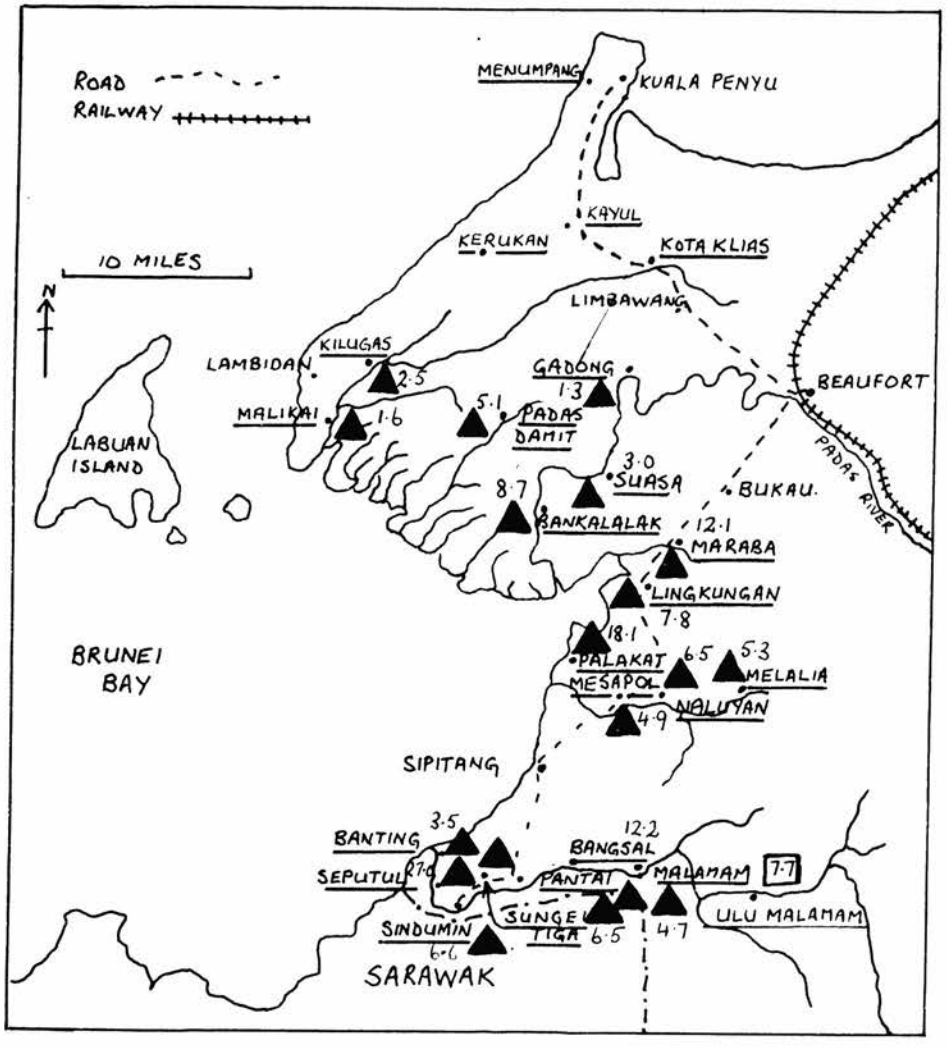
In 1963/4 while the writer was medical officer for the district, small surveys of filariasis were made in the area, and in addition approximately 1,500 patients admitted to Beaufort Hospital had night blood films examined for microfilariae. Infections due to B.malayi were found in patients from Limbawang, Gadong, Padas Damit, Bukau, Maraba, Sinapokan, Melikai and Lambidan. (Barclay, 1965.)

---

*Excluding those examined in 1963/64.

A number of B.malayi carriers from the Melikai area were treated with diethyl - carbamazine in 1965, and this may have affected the findings there in 1966/68.

Microfilaria and elephantiasis rates are given in Table 1.




Map 3 - Brunei Bay area

NOTE: On all maps kampongs surveyed are underlined:
Those in which filariasis was found are marked thus:-

B.malayi ▲

W.Bancrofti □

The figures adjacent to the symbols refer to the microfilaria rates in those kampongs.

TABLE 1

Microfilaria and elephantiasis rates - Brunei Bay area

| Kampong | No. examined | No. with microfilariae (all B.malayi) | No. with elephantiasis | Microfilaria rate % | Elephantiasis rate % |
|---|---|---|---|---|---|
| Padas Damit | 218 | 11 | 2 | 5.1 | 0.9 |
| Gadong | 76 | 1 | 1 | 1.3 | 1.3 |
| Bankalalak | 138 | 12 | 1 | 8.7 | 0.7 |
| Suasa | 234 | 7 | 1 | 3.0 | 0.4 |
| Maraba | 199 | 24 | 1 | 12.1 | 0.5 |
| Lingkungan | 217 | 17 | 1 | 7.8 | 0.5 |
| Palakat | 105 | 19 | 2 | 18.1 | 1.9 |
| Mesapol | 142 | 7 | - | 4.9 | - |
| Naluyan | 93 | 6 | 1 | 6.5 | 1.1 |
| Melalia | 76 | 4 | 1 | 5.3 | 1.3 |
| Seputul | 63 | 17 | 1 | 27.0 | 1.6 |
| Sungei Tiga | 50 | 4 | 2 | 8.0 | 4.0 |
| Banting | 167 | 6 | - | 3.5 | - |
| Sindumin | 181 | 12 | 2 | 6.6 | 1.1 |
| Pantai | 138 | 9 | 1 | 6.5 | 0.7 |
| Bangsal | 82 | 10 | - | 12.2 | - |
| Malamam | 169 | 8 | 1 | 4.7 | 0.6 |
| Menumpang | 120 | - | - | - | - |
| Kayul | 107 | - | - | - | - |
| Kerukan | 99 | - | - | - | - |
| Kota Klias | 165 | - | - | - | - |
| Kilugas | 198 | 4 | 1 | 2.0 | 0.5 |
| Malikai | 190 | 3 | - | 1.6 | - |
| TOTAL | 3227 | 181 | 19 | 5.6 | 0.6 |

## 2.2. Sugut, Labuk and Kinabatangan area (Map 4)

Estimated population 21,000

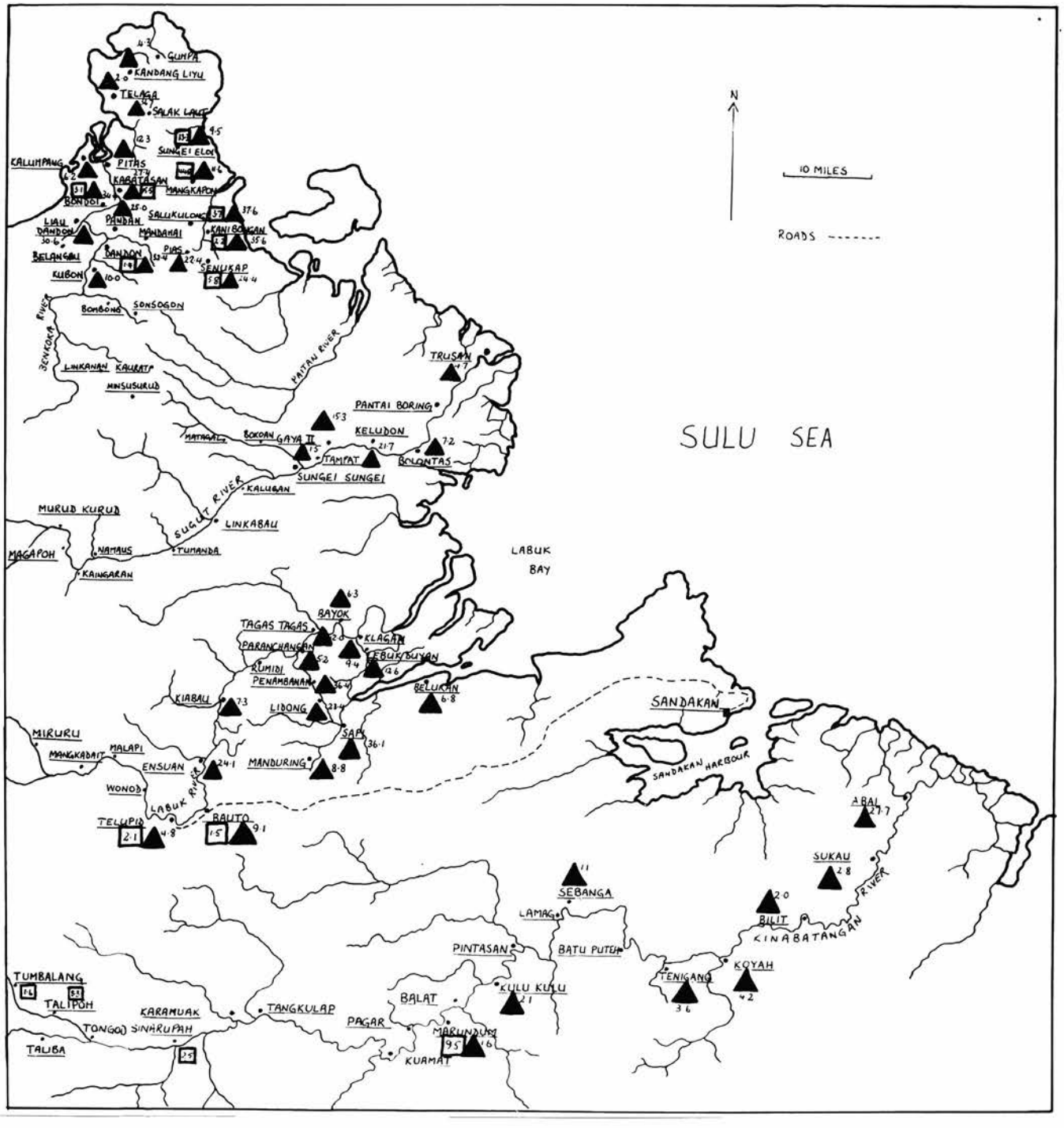
Number examined 3,117 (14.8%)

This area consists mainly of swamp forest. The inhabitants are mainly Kadazans, living in kampongs consisting of isolated houses strung out along the river bank, and engaging in shifting cultivation and fishing. Some of the men are employed intermittently in timber extraction, especially along the Kinabatangan river. Flooding of the Kinabatangan river occurs at least annually, and often more frequently, except at the mouth of the river: presumably by the time this point is reached, the flood water has already been dispersed over the low lying country further upstream.

Infections due to B.malayi were found to be endemic, the highest prevalence being found in the swampy delta near the mouth of the Labuk river, and at the mouth of the Kinabatagan river.

A few W.bancrofti infections were found in the upper part of the Labuk river. There is some traffic between this part and the Upper Kinabatangan river, where W.bancrofti infections are endemic, and this may be the source of the infection found. A small focus of W.bancrofti infection was found at Marundum.

Microfilaria and elephantiasis rates are given in Table 2.




MAP 4. - The north east : Benkoka and Sugut/Labuk/Kinabatangan areas.

Fig. 1. The Sugut river

Fig.2. Swamp forest along the Labuk river.

TABLE 2

Microfilaria and elephantiasis rates - Sugut/Labuk/Kinabatangan area.

| Kampong | No. examined | No. with microfilariae | | No. with elephantiasis | Microfilaria rate % | | Elephantiasis rate % |
|---|---|---|---|---|---|---|---|
| | | Bm | Wb | | Bm | Wb | |
| Tampat | 68 | 1 | - | - | 1.5 | - | - |
| Gaya 11 | 72 | 11 | - | - | 15.3 | - | - |
| Keludon | 60 | 13 | - | - | 21.7 | - | - |
| Bolontas | 139 | 10 | - | 1 | 7.2 | - | 0.7 |
| Pantai Boring | 97 | - | - | - | - | - | - |
| Trusan Sugut | 170 | 8 | - | 1 | 4.7 | - | 0.6 |
| Beluran | 44 | 3 | - | - | 6.8 | - | - |
| Manduring | 68 | 6 | - | - | 8.8 | - | - |
| Sapi | 155 | 56 | - | 3 | 36.1 | - | 1.9 |
| Lidong | 47 | 11 | - | - | 23.4 | - | - |
| Penambanan | 140 | 51 | - | 3 | 36.4 | - | 2.1 |
| Klagan | 53 | 5 | - | 3 | 9.4 | - | 5.7 |
| Lebuk Duyan | 87 | 11 | - | 2 | 12.6 | - | 2.3 |
| Bayok | 48 | 3 | - | 2 | 6.3 | - | 4.2 |
| Tagas Tagas | 83 | 10 | - | 3 | 12.0 | - | 3.6 |
| Paranchangan | 77 | 4 | - | - | 5.2 | - | - |
| Rumidi | 48 | - | - | - | - | - | - |
| Kiabau | 96 | 7 | - | - | 7.3 | - | - |
| Ensuan | 112 | 27 | - | - | 24.1 | - | - |
| Bauto | 66 | 6 | 1 | - | 9.1 | 1.5 | - |
| Telupid | 187 | 9 | 4 | - | 4.8 | 2.1 | - |
| Abai | 112 | 31 | - | 3 | 27.7 | - | 2.7 |
| Sukau | 36 | 1 | - | 1 | 2.8 | - | 2.8 |
| Bilit | 49 | 1 | - | - | 2.0 | - | - |
| Koyah | 120 | 5 | - | - | 4.2 | - | - |
| Tenigang | 84 | 3 | - | - | 3.6 | - | - |
| Batu Puteh | 88 | - | - | - | - | - | - |
| Sahanga | 88 | 1 | - | - | 1.1 | - | - |
| Lamat | 150 | - | - | - | - | - | - |
| Pintasan | 37 | - | - | - | - | - | - |
| Kulu Kulu | 48 | 1 | - | - | 2.1 | - | - |
| Balat | 84 | - | - | - | - | - | - |
| Marundum | 127 | 2 | 12 | - | 1.6 | 9.5 | - |
| Pagar | 33 | - | - | - | - | - | - |
| Kuamat | 72 | - | - | - | - | - | - |
| Tangkulap | 32 | - | - | - | - | - | - |
| Karamuak | 39 | - | - | - | - | - | - |
| TOTAL | 3116 | 297 | 17 | 22 | 9.5 | 0.5 | 0.7 |

## 2.3. Benkoka area (Map 4)

Estimated population 10,000

Number examined 1,159 (11.6%)

This area is the peninsula to the east of Marudu Bay. A low range of hills runs north-south. To the west flows the Benkoka river, alongside which there is much swamp forest. To the east the coastal fringe is broader, and in addition to the swamp forest there are many low hills covered with primary forest. The inhabitants are Rungus Kadazans, dwelling in long houses and engaging in shifting cultivation and hunting.

In 1964 the then Medical Officer, Kudat, reported finding infections due to both B.malayi and W.bancrofti in the area. During the 1966/68 investigation B.malayi was found to be widespread throughout the area. W.bancrofti infections were also found, but these were mainly limited to the central and eastern parts of the peninsula. In several kampongs both species of parasite were found, and mixed infections in the one patient were not uncommon.

Microfilaria and elephantiasis rates are given in Table 3.

TABLE 3

Microfilaria and elephantiasis rates - Benkoka area

| Kampong | No. examined | No. with microfilariae | | | No. with elephantiasis | Microfilaria rate % | | Elephantiasis rate % |
|---|---|---|---|---|---|---|---|---|
| | | Bm | Wb | Mixed | | Bm* | Wb* | |
| Mempakat | 78 | - | - | - | - | - | - | - |
| Belangau | 24 | - | - | - | - | - | - | - |
| Kubon | 40 | 4 | - | - | - | 10.0 | - | - |
| Mandamai | 13 | - | - | - | - | - | - | - |
| Dandon | 74 | 23 | - | 1 | - | 32.4 | 1.4 | - |
| Pandan | 24 | 6 | - | - | - | 25.0 | - | - |
| Liau Dandon | 49 | 15 | - | - | 1 | 30.6 | - | 2.0 |
| Kabatasan | 84 | 15 | 5 | 8 | 1 | 27.4 | 15.5 | 1.2 |
| Bondoi | 32 | 10 | - | 1 | - | 34.4 | 3.1 | - |
| Kalumpang | 65 | 4 | - | - | - | 6.2 | - | - |
| Pitas | 57 | 7 | - | - | 2 | 12.3 | - | 3.5 |
| Salak Laut | 30 | 11 | - | - | - | 36.7 | - | - |
| Telaga | 102 | 2 | - | - | - | 2.0 | - | - |
| Kandang Liyu | 70 | 3 | - | - | - | 4.3 | - | - |
| Gumpa | 64 | - | - | - | 1 | - | - | - |
| Sungei Eloi | 21 | 2 | 7 | - | - | 9.5 | 33.3 | 4.8 |
| Mangkapon | 43 | - | 14 | 5 | 1 | 11.6 | 44.2 | - |
| Salukulong | 109 | 37 | - | 4 | 3 | 37.6 | 3.7 | 0.9 |
| Kanibongan | 45 | 15 | - | 1 | - | 35.6 | 2.2 | 6.7 |
| Pias | 49 | 11 | - | - | - | 22.4 | - | - |
| Senukap | 86 | 17 | 1 | 4 | - | 24.4 | 5.8 | - |
| TOTAL | 1159 | 182 | 27 | 24 | 9 | 17.8 | 4.7 | 0.8 |

Note: Bm = B.malayi Wb = W.bancrofti *Including mixed infections

## 2.4. The south east (Map 5)

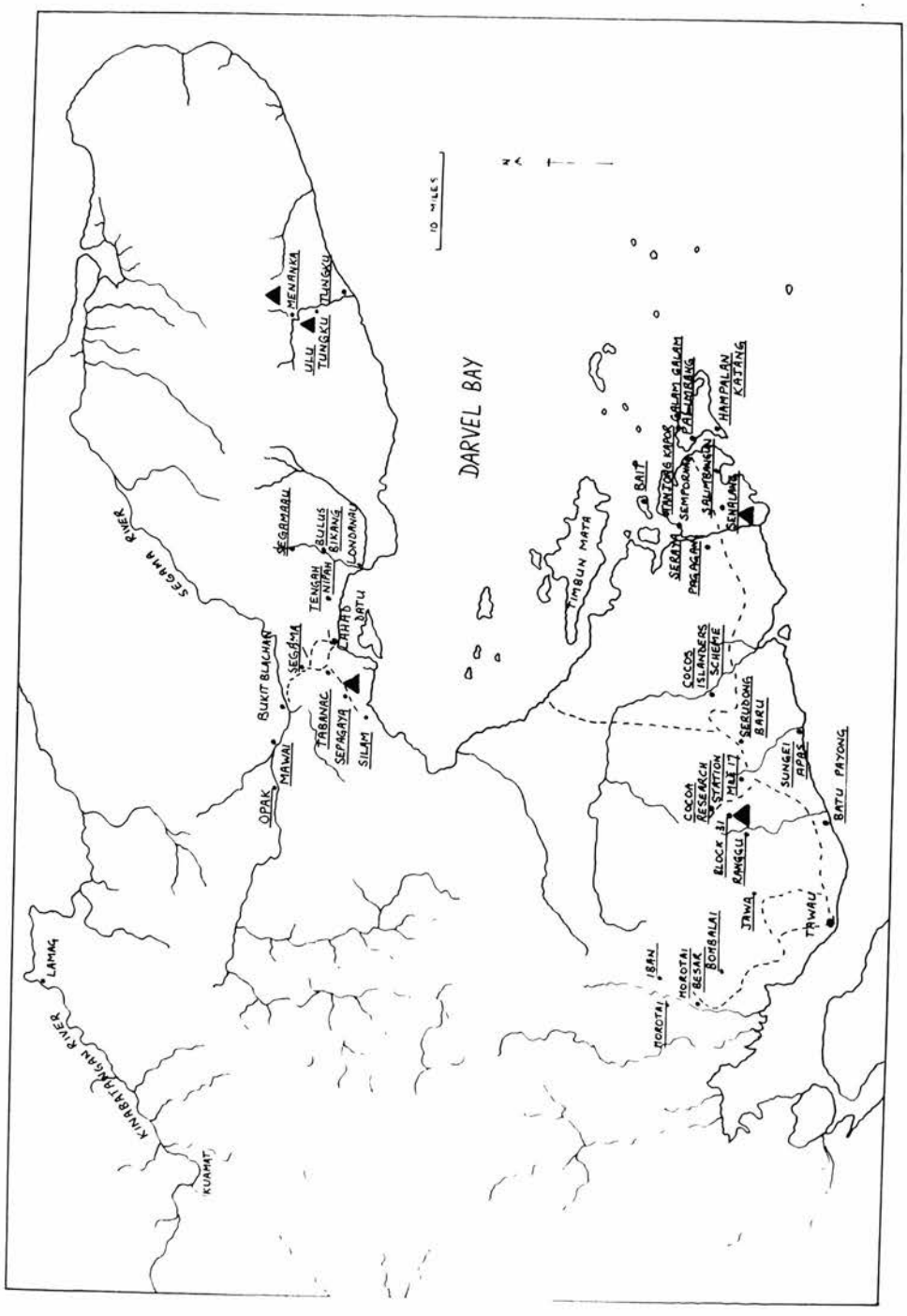
Estimated population 86,000

Number examined 4,961 (5.8%)

Around Lahad Datu, Tawau and Semporna there are large cleared settled areas where rubber, cocoa, coffee, coconuts and abaca are grown. The population is a mixed one consisting mainly of immigrants, either from other parts of Sabah or from the neighbouring countries of Indonesia and the Philippines. The indigenous population is found around Semporna, and in various small settlements round Darvel Bay. They are engaged mainly in fishing and coastal trading - and until recently in smuggling and piracy. They form a strong Muslim group, traditionally hostile to others, and prone to violence.

The remainder of the area is uninhabited.

Sporadic infections due to B.malayi were found at Sepagaya (2 of 36 examined), Menanka (1 of 177), Ulu Tungku (1 of 160), Block 31 Settlement Scheme (2 of 216) and Senalang (1 of 165).



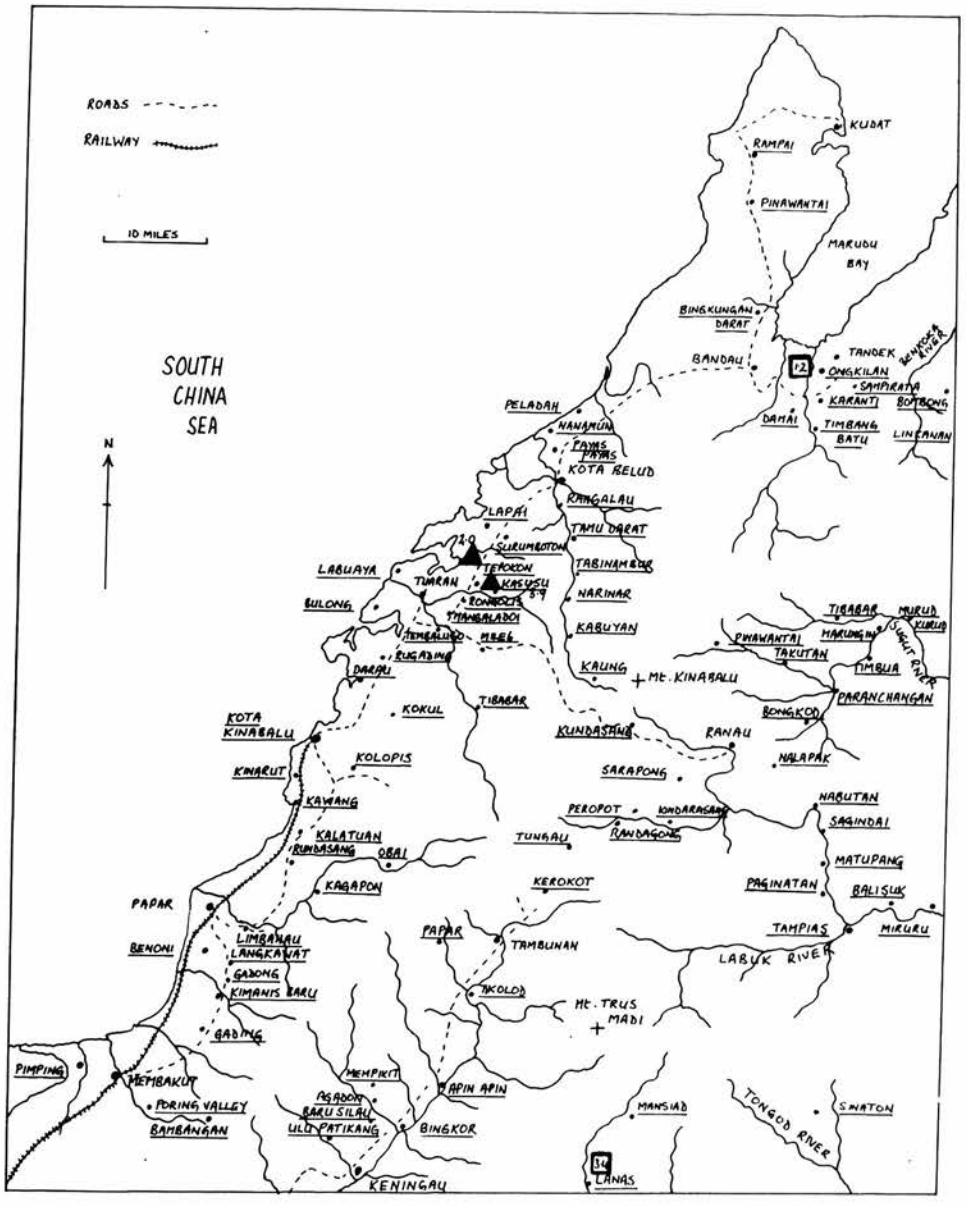

MAP 5. - The south east

## 2.5. The west coast (Map 6.)

Estimated population 250,000

Number examined* 5,388 (2.2%)

This area is formed by the low foothills west of the Crocker range, and the coastal strip between that range and the sea. It extends northwards from Membakut to Kudat and includes Labuan Island.




MAP 6 - The west coast

*Excluding those examined in 1964, and hospital patients examined in 1966/68.

It is the most densely populated part of the country and the inhabitants are mainly Kadazans. Wet rice is grown on the flat land, and rubber in the foothills. There is practically no primary forest in the area except for a small patch of swamp forest near Tuaran. Even in the hills where rubber is not grown, generations of shifting cultivators have cleared the primary forest, and this has been replaced by secondary growth.

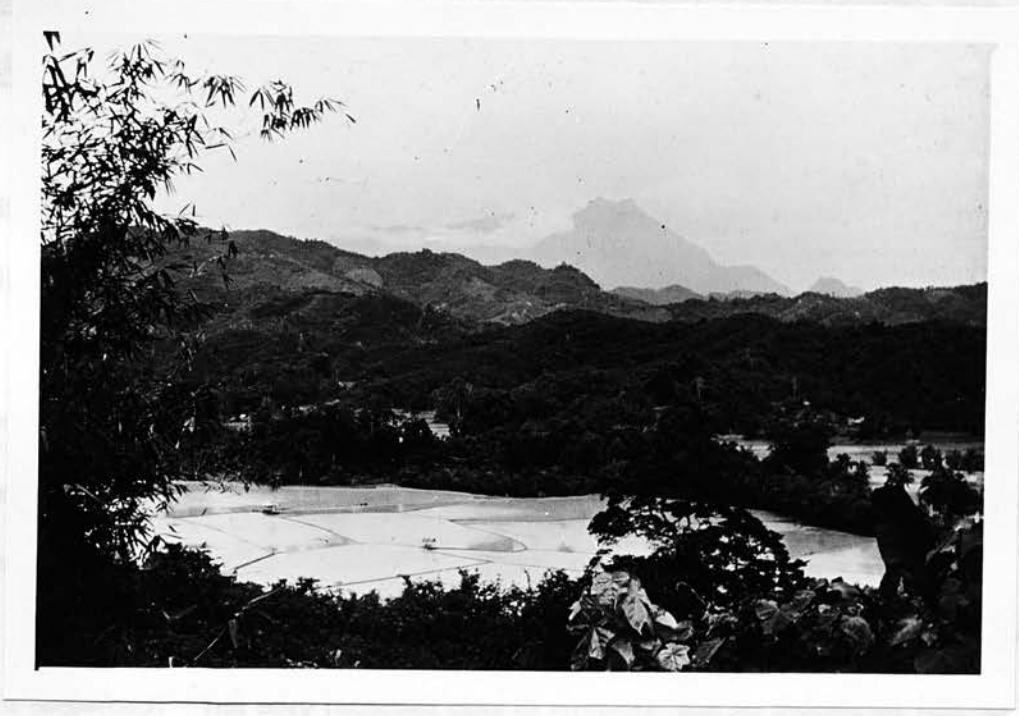


Fig. 3 The west coast

Rice growing in the foreground, and rubber on the lowhills adjacent to the rice fields.
Note the absence of primary forest on the hills in the middle distance.
Mt. Kinabalu in the background.

In 1964 the then Medical Officer, Kudat, examined night blood films from 1,943 patients admitted to Kudat Hospital. Among the patients from the Kudat peninsula (and these formed the bulk of the 1,943 examined) two filarial infections were found. Both these patients originated from the Benkoka area, and it is likely that they were infected there, as filariasis is known to be endemic in that area. Infections due to B.malayi and W.bancrofti were found in patients from the Benkoka area, and W.bancrofti infections in those from Banggi Island.

In 1964 approximately 1,000 patients admitted to the hospital in Labuan while the writer was medical officer there, had night blood films examined. No infections indigenous to the island were found.

During the 1966/68 investigation numerous kampongs other than those from which blood films were taken were visited and enquiries made about the presence or absence of evidence of filarial infections. Any reports of swollen limbs, scrotums, etc., were investigated: all proved to be due to causes other than filariasis.

The records of the Queen Elizabeth Hospital, Kota Kinabalu, from 1963 onwards were examined. The only recorded case of filariasis was an incidental finding in a woman from Kolopis: in 1966, 229 people from this kampong were examined, and filariasis was not found.

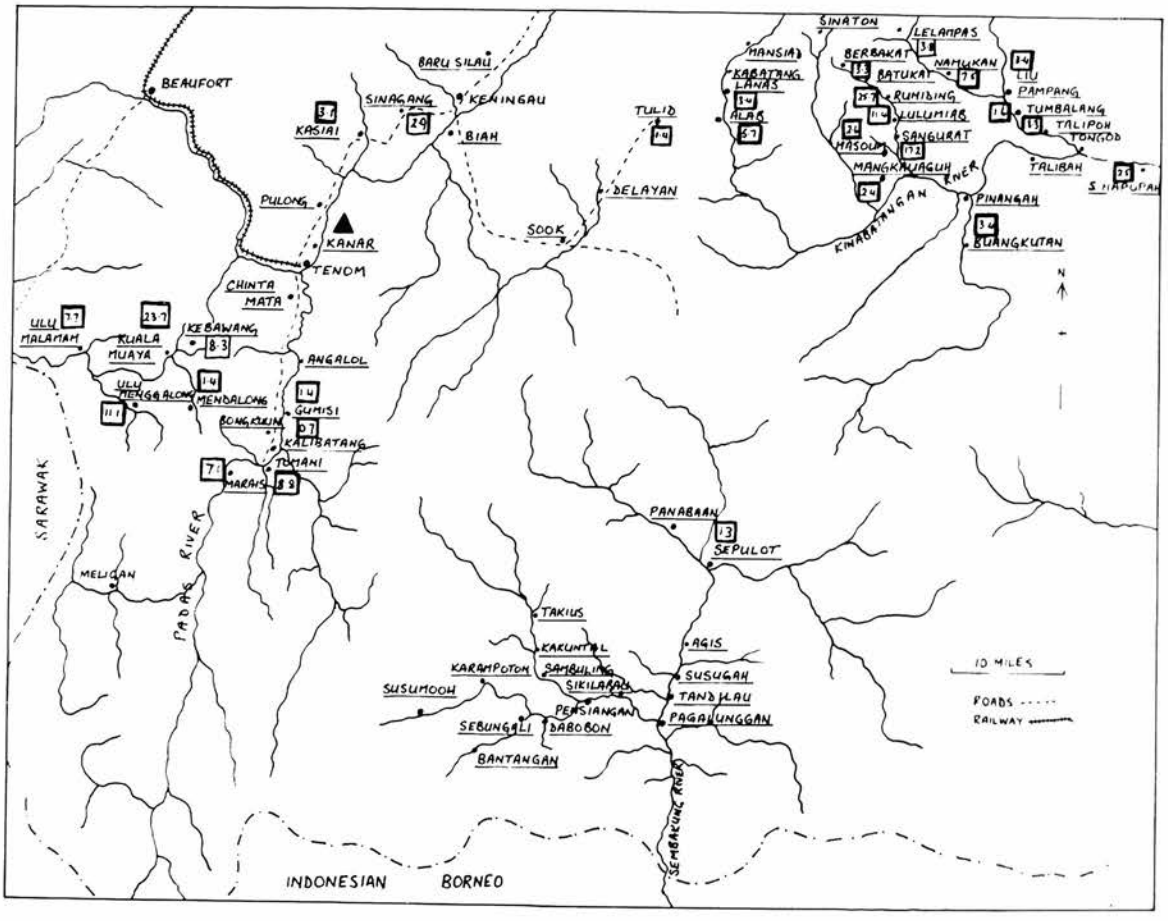
In addition to the blood films collected in field surveys, 1,142 night blood films from patients admitted to the Queen Elizabeth Hospital, Kota Kinabalu, were examined. None were found to contain microfilariae.

Four infections due to B.malayi were found in kampongs Tepokon and Kasusu in Tuaran district, adjacent to the only swamp forest in the area, and 3 due to W.bancrofti

in kampong Ongkilan at the foot of Marudu Bay.

## 2.6. The interior.

During the past 20 years efforts have been made to introduce better agricultural methods, and cash crops into the interior, and now, around Ranau, Tambunan and Keningan there are large cleared areas of wet rice, with rubber growing on the hills fringing these plains. The valleys north and south of Tenon are fertile and here rice, rubber, coffee and fruit are grown.




Map 7. The southern part of the interior.

Fig.4. Ranau, one of the cultivated plains of the interior.

Fig. 5. The mountainous interior - Upper Kinabatangan region

The remainder of the interior consists mainly of jungle covered mountains, and communications are very difficult. The swift flowing rocky rivers are often impassable even to small canoes, and what tracks there are, are ill-defined and overgrown. The people live a primitive existence, subsisting on shifting cultivation and hunting. In the south, round Pensiangan, and in the upper Kinabatangan basin, live the Muruts, and to the north, Kadazans. In the past head hunting was common among both groups, but has not been practiced extensively for many years. Much of the small rice crop grown is turned into alcohol, and malnutrition is common. Prolonged drinking bouts are often followed by fights, occasionally with fatal results. The visit of strangers is often made an occasion for staging one of these bouts, and though this helped to draw the population together for examination, it also added to the hazards of the enterprise.

The people were not so much hostile as suspicious, and it was difficult to make them understand the purpose of the survey.

W.bancrofti infections were found to be endemic in the upper Kinabatangan region and round Tomani and the neighbouring watershed (Map 7 ). One infection with W.bancrofti was found at Sepulot, probably imported from elsewhere. The only infection with B.malayi was in a man who had worked intermittently on rubber estates in the Brunei Bay area, and it is likely that he was infected there.

In the upper Kinabatangan region the people were familiar with scrotal swelling, and though prepared to report its occurrence in other neighbouring villages, were reluctant to admit that it occurred in their own village. The impression gained was that hydrocele did occur not uncommonly, but it was impossible to assess the prevalence. Elephantiasis of the limbs was rarely reported or seen.

In the Tomani area better co-operation was secured, probably because of a higher level of education and a greater familiarity with medical work, and the presence of an authoritative Native Chief, sympathetic towards the aims of the survey. It is thought that the information gathered there is reliable.

Microfilaria and clinical filariasis rates in the Upper Kinabatagan/Tomani area are listed in Table 4.

In other parts of the interior, filariasis was not found nor were symptoms likely to be due to filariasis often reported.

2.7. Sandakan.

Night blood films from 1,042 patients admitted to the Duchess of Kent Hospital, Sandakan, were examined for microfilariae: no infections were found from the area.

2.8. Banggi Island.

Of 273 blood films examined from Banggi Island, 3 contained microfilariae of W.bancrofti.

2.9. Summary of distribution.

Infections due to sub-periodic B.malayi were found to be endemic in the Brunei Bay area in the south-west, and in the Benkoka area and the lower reaches of the Sugut, Labuk and Kinabatangan rivers in the north-east. Sporadic infections were found in the south-east part of the country, and near Tuaran on the west coast.

W.bancrofti infections were found to be endemic in the Benkoka area in the north-east, in the basin of the Upper Kinabatangan river, and around the watershed at the south-west end of the Crocker range from which drain the Menggalong river and

TABLE 4

Microfilaria and clinical filariasis rates - upper Kinabatangan and Tomani areas.

| Kampong | No. examined | No. with microfilariae (all W.bancrofti) | No. with clinical filariasis | Microfilaria rate % | Clinical filariasis rate % |
|---|---|---|---|---|---|
| Sinarupah | 81 | 2 | - | 2.5 | - |
| Taliba | 27 | - | - | - | - |
| Buangkutan | 59 | 2 | - | 3.4 | - |
| Pinangah | 80 | - | - | - | - |
| Masoum | 38 | 1 | - | 2.6 | - |
| Mangkauaguh | 41 | 1 | - | 2.4 | - |
| Lulumiab | 44 | 5 | - | 11.4 | - |
| Sangurat | 58 | 10 | - | 17.2 | - |
| Rumiding | 70 | 18 | - | 25.7 | - |
| Batukat | 60 | 2 | - | 3.3 | - |
| Talipoh | 30 | 1 | - | 3.3 | - |
| Tumbalang | 64 | 1 | - | 1.6 | - |
| Liu Pampang | 117 | 4 | - | 3.4 | - |
| Namukan | 146 | 11 | - | 7.5 | - |
| Lelampas | 79 | 3 | - | 3.8 | - |
| Alab | 158 | 9 | 1 | 5.7 | 0.6 |
| Lanas | 146 | 5 | 1 | 3.4 | 0.7 |
| Kabatang | 91 | - | - | - | - |
| Mansiad | 121 | - | - | - | - |
| Berbakat | 60 | - | - | - | - |
| Sinaton | 107 | - | - | - | - |
| Ulu Malamam | 26 | 2 | 1 | 7.7 | 3.8 |
| Mendalong | 72 | 1 | 2 | 1.4 | 2.8 |
| Ulu Mengga-long | 72 | 8 | - | 11.1 | - |
| Kebawang | 36 | 3 | 1 | 8.3 | 2.8 |
| Kuala Muaya | 38 | 9 | 3 | 23.7 | 7.9 |
| Marais | 70 | 5 | 2 | 7.1 | 2.9 |
| Tomani | 102 | 9 | 6 | 8.8 | 5.9 |
| Kalibatang | 136 | 1 | - | 0.7 | - |
| Bangkulin | 102 | - | - | - | - |
| Gumisi | 71 | 1 | - | 1.4 | - |
| TOTAL | 2402 | 114 | 17 | 4.7 | 0.7 |

tributaries of the Padas river. Sporadic infections were found in kampongs related to these main endemic areas, and two small foci of infection were found in the neighbourhood of Keningau.

In the south-east part of the country there are many Timorese immigrants. Recently a new microfilaria has been found in man in Timor (David and Edeson, 1965). This microfilaria was not found in the Timorese examined in Sabah.

## 3. The parasites

### 3.1 Brugia malayi

#### 3.1.1 Morphology and staining.

In thick blood films, dried and stained in the manner described in section 1.5, the microfilariae showed the irregular curves and kinking characteristic of B.malayi (Brug, 1928; Wilson, 1956). The nuclei were densely packed, purple-staining and rather ill-defined. The nerve ring, excretory pore and anus were clearly seen. The tail tapered into a thread-like appendage containing either one or two terminal nuclei; not uncommonly the body overlay the tail and obscured these nuclei.

Most of the microfilariae retained their sheaths, and these stained bright pink. The retaining of the sheath on most of the parasites is characteristic of the sub-periodic form of B.malayi (Wilson et al, 1958).

#### 3.1.2. Periodicity.

Fig. 6. Microfilaria of B.malayi - Giemsa stained thick blood film.

Fig. 7. Microfilaria of W.bancrofti - Giemsa stained thick blood film.

Because of the lack of hospital patients suffering from filariasis, periodicity studies had to be made, with difficulty, in the field. Four-hourly blood films were obtained from 7 patients. The results of these studies are presented in Table 5.

TABLE 5

Periodicity of microfilariae of B.malayi

| Patient No. | 08.00 hrs. | 12.00 hrs. | 16.00 hrs. | 20.00 hrs. | 24.00 hrs. | 04.00 hrs |
|---|---|---|---|---|---|---|
| 1 | 12 | 7 | 70 | 151 | 161 | 91 |
| 2 | 8 | 1 | 8 | 15 | 17 | 15 |
| 3 | 59 | 21 | 50 | 122 | 74 | 56 |
| 4 | 8 | 1 | 3 | 41 | 26 | 23 |
| 5 | 40 | 14 | 76 | 76 | 72 | 119 |
| 6 | 30 | 48 | 37 | 168 | 116 | 75 |
| 7 | 3 | 4 | 87 | 22 | 57 | 10 |

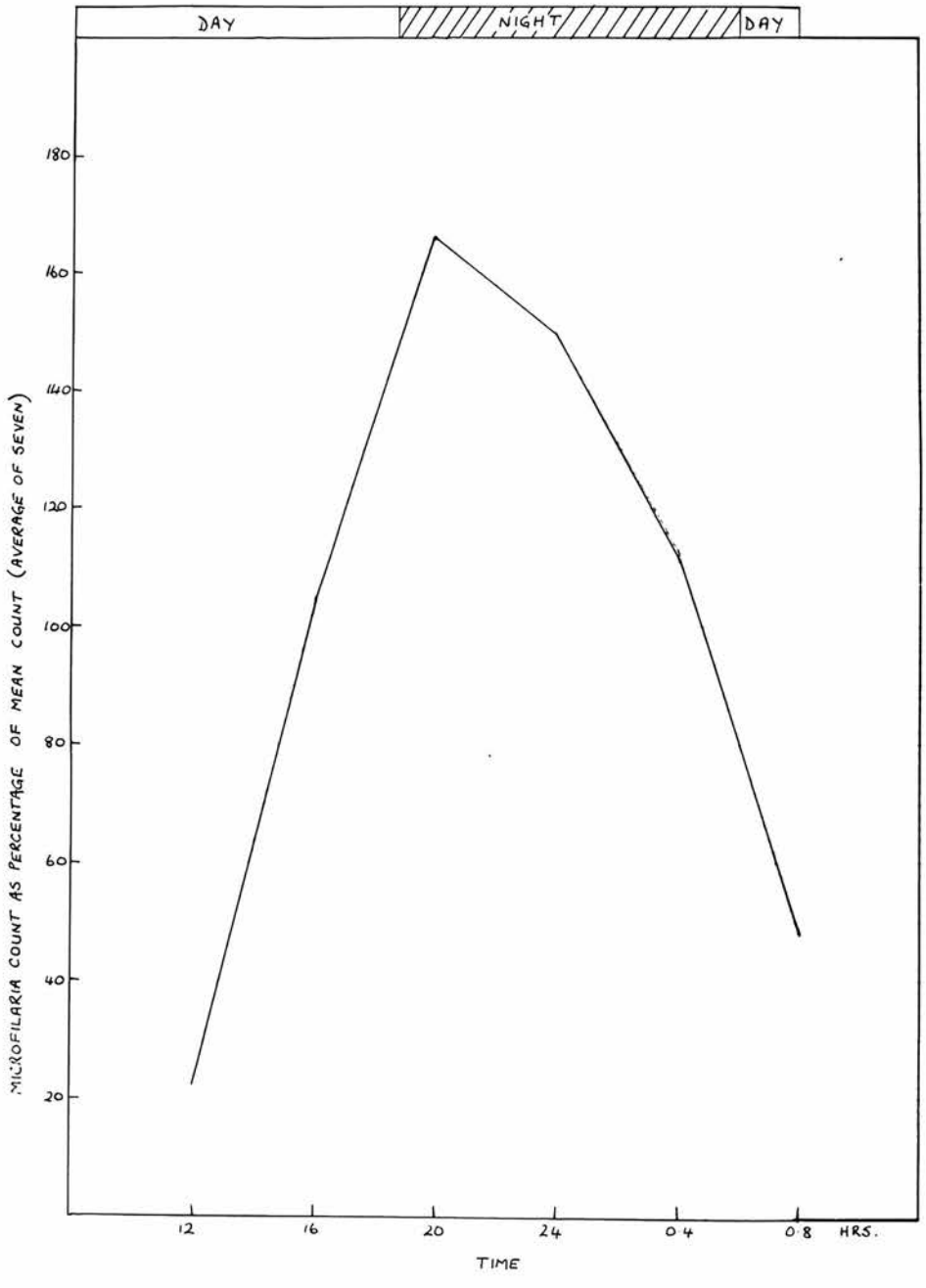
In addition, in a further 14 patients, day and night films were taken between 1900 and 2100 hours and 1000 and 1200 hours. All films contained microfilariae, though there were reduced numbers in daytime films.

From these results it appears that B.malayi in Sabah is nocturnally sub-periodic.

## 3.2. Wuchereria bancrofti

### 3.2.1. Morphology and staining.

In air dried thick blood films stained with dilute giemsa stain, the microfilariae presented the smooth graceful curves, the discrete, blue staining nuclei, and the




Graph 1. Periodicity of B.malayi

absence of staining of the sheath typical of W.bancrofti (Wilson, 1958). That the microfilariae were in fact sheathed was shown by de-colouring and re-staining with Haemalum.

### 3.2.2. Periodicity

In the areas where W.bancrofti occurred it was even more difficult to carry out periodicity studies than in the B.malayi infected areas, and in only 3 patients was it possible to obtain 4-hourly blood films. The results are presented in Table 6.

TABLE 6.

No. of microfilariae per 20 cmm. of blood

| Patient No. | 08.00 hrs. | 12.00 hrs. | 16.00 hrs. | 20.00 hrs. | 24.00 hrs. | 04.00 hrs |
|---|---|---|---|---|---|---|
| 8 | 0 | 0 | 0 | 20 | 73 | 4 |
| 9 | 0 | 0 | 0 | 9 | 41 | 2 |
| 10 | 0 | 0 | 0 | 4 | 23 | 5 |

Day and night films were obtained from a further 7 infected people: no microfilariae were found in day blood films. It is concluded that W.bancrofti in Sabah is nocturnally periodic.

## 4. The human host

### 4.1. B.malayi

### 4.1.1 Clinical manifestations.

In the areas where B.malayi infections occurred, complaints of repeated attacks of fever associated with lymphangitis and sometimes transient swellings of the limbs

were not uncommon. These complaints were not met with in other areas, and it seems likely that filariasis was the cause. The syndrome were associated by the kampong people with elephantiasis, and known as "untut". Few people had this complaint at the time of the team's visit, and it is difficult to assess the incidence by hearsay. Some appeared to suffer these recurrent bouts of fever and lymphangitis for a period of months or years, followed by spontaneous remission without the development of elephantiasis. Others developed elephantiasis, usually of the lower limbs, not extending above the knee, and of relatively mild degree. The onset of elephantiasis was sometimes associated with a reduction in frequency and severity of the attacks of fever, and sometimes with the complete disappearance of these symptoms.

Most of those infected seemed to suffer no ill effects.

Elephantiasis may affect one or both legs. Only one patient was seen with elephantiasis of the arm. Two people were found to have hydrocele, which may have been caused by filariasis. Modesty may have prevented the disclosure of information about other genital lesions. The frequency with which lesions of the different parts of the body was seen is summarized in Table 7.

TABLE 7.

Distribution of lesions seen in B.malayi endemic areas

| | Affected Region | | | | |
|---|---|---|---|---|---|
| | Left arm | Left leg | Right leg | Both legs | Scrotum |
| No. seen | 1 | 16 | 15 | 16 | 2 |
| % of total seen | 2% | 32% | 30% | 32% | 4% |

4.1.2. The effect of age and sex on the elephantiasis rate, the microfilaria rate, and microfilaria densities.

Microfilaria and elephantiasis rates by age and sex from the Brunei Bay and Sugut/Labuk/Kinabatangan areas are presented in Table 8 and the range of microfilaria counts and the median microfilaria count, by age and sex, in Table 9 and graph 3 Figures obtained from the Benkoka area have been excluded, as here both B.malayi and W.bancrofti occur: the clinical effects seen could be due to either parasite, and it is not known what effect the presence of mixed infections has on microfilaria densities. Figures for this area are presented separately in Table 10. The figures from the Kuala Penyu area of Brunei Bay have also been excluded because treatment of microfilaria carriers in this area was carried out in 1965.

In males the microfilaria rate rose until the 35-39 age group, and fell thereafter, with a further rise in those over 55 years. The elephantiasis rate showed a gradual increase with age.

The microfilaria density, as judged by the median count*, rose until the 25-29 age group and thereafter decreased with advancing age.

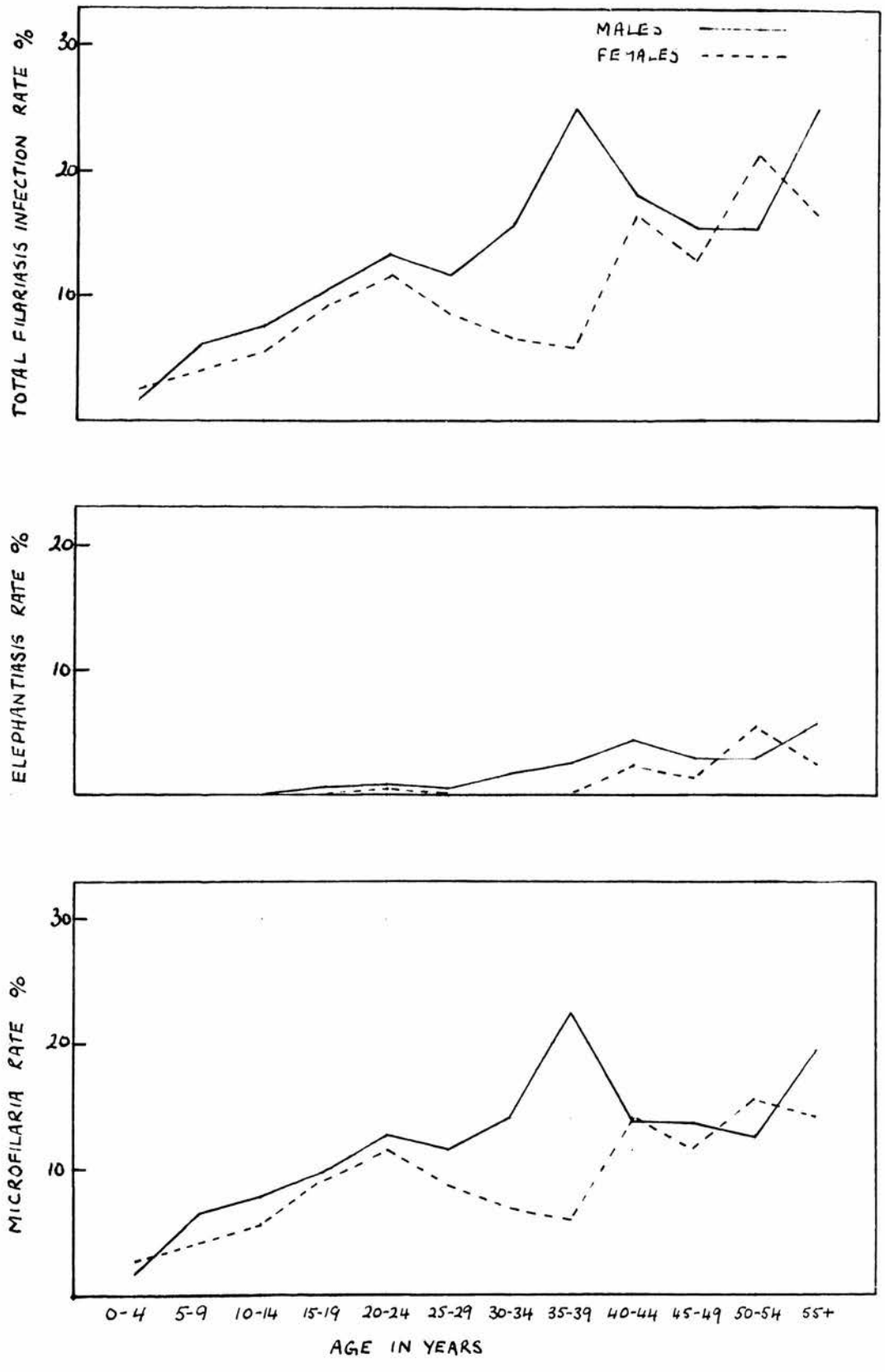
---

*There is no agreed method of presenting microfilaria densities. The mean microfilaria count per measured quantity of blood has been used, but it is felt that this is likely to be influenced unduly by the occasional very high count. An Expert Committee on Filariasis set up by the World Health Organization recommend that all microfilaria counts be tabulated, and a regression line drawn from which the median microfilaria count can be derived: this they regard as the most reliable criterion for comparison of the densities of different populations (WHO, 1967). This method is suitable for large populations, but for the purpose of demonstrating differences in microfilaria densities in the small groups covered in this survey, the median microfilaria count derived by more straightforward methods has been used.

TABLE 8.

Microfilaria and elephantiasis rates by age and sex - B.malayi endemic areas

| Age in years | Sex | No. examined | No. with microfilariae (All B.malayi) | No. with elephantiasis | Microfilaria rate % | Elephantiasis rate % |
|---|---|---|---|---|---|---|
| 0-4 | M | 410 | 6 | - | 1.5 | - |
| | F | 350 | 8 | - | 2.3 | - |
| 5-9 | M | 528 | 32 | - | 6.1 | - |
| | F | 425 | 17 | - | 4.0 | - |
| 10-14 | M | 517 | 40 | - | 7.7 | - |
| | F | 364 | 20 | - | 5.5 | - |
| 15-19 | M | 253 | 25 | 1 | 9.9 | 0.4 |
| | F | 253 | 23 | - | 9.1 | - |
| 20-24 | M | 259 | 32 | 2 | 12.4 | 0.8 |
| | F | 221 | 25 | 1 | 11.3 | 0.5 |
| 25-29 | M | 236 | 27 | 1 | 11.4 | 0.4 |
| | F | 224 | 20 | - | 8.9 | - |
| 30-34 | M | 221 | 31 | 4 | 14.0 | 1.8 |
| | F | 173 | 12 | - | 6.9 | - |
| 35-39 | M | 160 | 36 | 4 | 22.5 | 2.5 |
| | F | 133 | 8 | - | 6.0 | - |
| 40-44 | M | 144 | 21 | 6 | 13.9 | 4.2 |
| | F | 93 | 13 | 2 | 14.0 | 2.2 |
| 45-49 | M | 102 | 14 | 4 | 13.7 | 3.9 |
| | F | 70 | 8 | 1 | 11.4 | 1.4 |
| 50-54 | M | 72 | 9 | 2 | 12.5 | 2.8 |
| | F | 57 | 9 | 3 | 15.8 | 5.3 |
| 55 + | M | 128 | 25 | 7 | 19.5 | 5.5 |
| | F | 71 | 10 | 2 | 14.1 | 2.5 |
| TOTAL | M | 3030 | 298 | 31 | 9.8 | 1.0 |
| | F | 2434 | 173 | 9 | 7.1 | 0.4 |
| Both sexes | | 5464 | 471 | 40 | 8.6 | 0.7 |

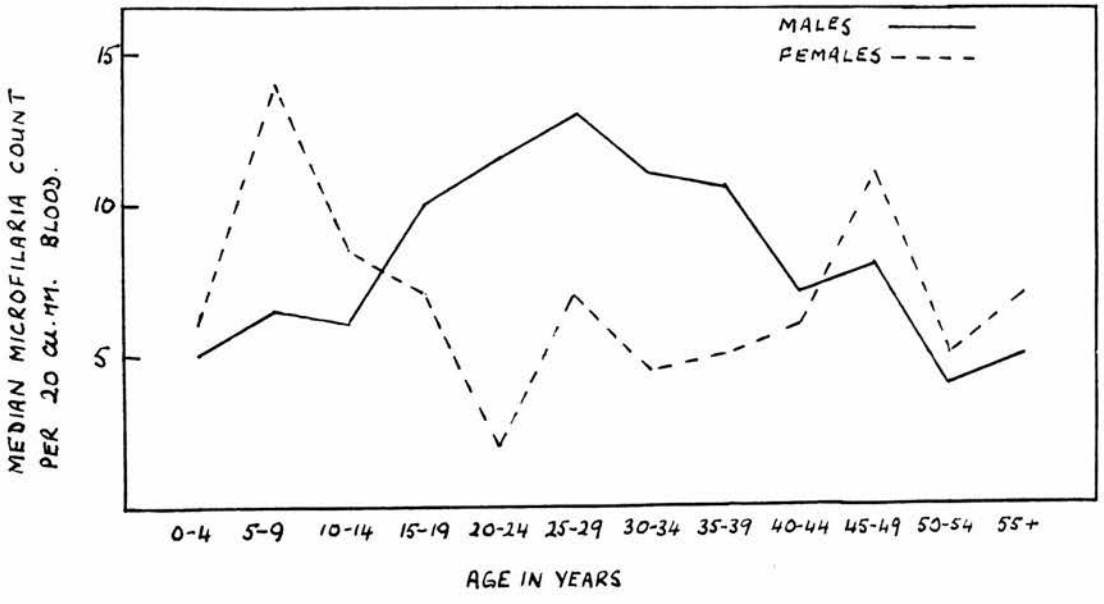



Graph 2. Microfilaria and elephantiasis rates by age and sex - B.malayi endemic areas

TABLE 9.

Range of microfilaria count and median microfilaria count per 20 cu.mm.by age and sex

| Age in years | Sex | No. with microfilariae | Range of microfilaria counts per 20 cu.mm. blood. | Median microfilaria count per 20 cu.mm. blood |
|---|---|---|---|---|
| 0-4 | M | 6 | 1-8 | 5 |
| | F | 8 | 1-33 | 6 |
| 5-9 | M | 32 | 1-208 | 7 |
| | F | 17 | 1-172 | 14 |
| 10-14 | M | 40 | 1-303 | 6 |
| | F | 20 | 1-89 | 9 |
| 15-19 | M | 25 | 1-72 | 10 |
| | F | 23 | 1-62 | 7 |
| 20-24 | M | 32 | 1-185 | 12 |
| | F | 25 | 1-75 | 2 |
| 25-28 | M | 27 | 1-84 | 13 |
| | F | 20 | 1-80 | 7 |
| 30-34 | M | 31 | 1-157 | 7 |
| | F | 12 | 1-29 | 5 |
| 35-39 | M | 36 | 1-195 | 11 |
| | F | 8 | 1-36 | 5 |
| 40-44 | M | 21 | 1-42 | 7 |
| | F | 13 | 1-52 | 6 |
| 45-49 | M | 14 | 1-92 | 8 |
| | F | 8 | 1-49 | 13 |
| 50-54 | M | 9 | 1-21 | 4 |
| | F | 9 | 1-131 | 5 |
| 55 + | M | 25 | 1-121 | 5 |
| | F | 10 | 3-29 | 7 |




Graph 3. Median microfilaria counts by age and sex - B.malayi.

TABLE 10

Microfilaria and elephantiasis rates by age and sex, Benkoka area

| Age in years | Sex | No. examined | No. with microfilariae | | | No. with elephantiasis | Microfilaria rate % | | Elephantiasis rate % |
|---|---|---|---|---|---|---|---|---|---|
| | | | Bm | Wb | Mixed | | Bm | Wb | |
| 0-4 | M | 42 | 5 | | | - | 11.9 | - | - |
| | F | 23 | 1 | - | - | - | 4.3 | - | - |
| 5-9 | M | 93 | 12 | - | 2 | - | 15.1 | 2.2 | - |
| | F | 82 | 13 | - | - | - | 15.9 | - | - |
| 10-14 | M | 118 | 21 | 3 | 2 | - | 19.5 | 4.2 | - |
| | F | 71 | 11 | - | - | - | 15.3 | - | - |
| 15-19 | M | 64 | 11 | - | 1 | - | 18.8 | 1.6 | - |
| | F | 45 | 4 | 2 | - | - | 8.9 | 4.4 | - |
| 20-24 | M | 52 | 6 | 3 | 2 | - | 15.4 | 9.6 | - |
| | F | 56 | 6 | 2 | 1 | - | 12.5 | 5.4 | - |
| 25-29 | M | 81 | 18 | 3 | 5 | - | 28.4 | 9.9 | - |
| | F | 74 | 7 | 2 | - | - | 9.5 | 2.7 | - |
| 30-34 | M | 58 | 9 | 2 | 2 | 1 | 19.0 | 6.9 | 1.7 |
| | F | 29 | 4 | 1 | 1 | - | 17.2 | 6.9 | - |
| 35-39 | M | 57 | 11 | 2 | 4 | 1 | 26.3 | 10.5 | 1.8 |
| | F | 37 | 5 | 1 | - | - | 13.5 | 2.7 | - |
| 40-44 | M | 48 | 12 | 3 | 1 | 2 | 27.1 | 8.3 | 4.3 |
| | F | 28 | 4 | 1 | 1 | 1 | 17.9 | 7.1 | 3.6 |
| 45-49 | M | 34 | 10 | - | 1 | 1 | 32.4 | 2.9 | 2.9 |
| | F | 10 | - | 1 | - | 1 | - | 10.0 | 10.0 |
| 50-54 | M | 18 | 5 | - | - | 1 | 27.8 | - | 5.6 |
| | F | 7 | 2 | - | - | - | 28.6 | - | - |
| 55 & over | M | 19 | 5 | 1 | 1 | 1 | 31.6 | 10.5 | 5.3 |
| | F | 13 | - | - | - | - | - | - | - |
| TOTAL | | 1159 | 18 | 27 | 24 | 9 | 17.8 | 4.7 | 0.8 |

In females the microfilaria rate rose until the 20-24 year age group, and from then fell until the 35-39 year age group, and rose steadily thereafter. The elephantiasis rate showed a gradual rise with increasing age.

The microfilaria density rose until the 5-9 year age group and then fell till the 20-24 year age group, and thereafter showed a steady rise with age.

## 4.2. W.bancrofti

### 4.2.1. Clinical manifestations.

In the Upper Menggalong/Tomani area, where W.bancrofti is endemic, hydrocele was common. Of the 15 people seen with clinical lesions, 10 had hydrocele and 5 had elephantiasis of both legs. In 4 of the patients with elephantiasis the swelling of the leg extended above the knee, in one or both limbs. None of those with elephantiasis had microfilariae in their blood. Of the 10 with hydrocele, 2 had microfilaraemia.

In the other areas where W.bancrofti infections were found, clinical manifestation of disease was rarely seen, and this is thought to be due to a reluctance to disclose such information rather than an absence of disease, as mentioned in section 2.6.

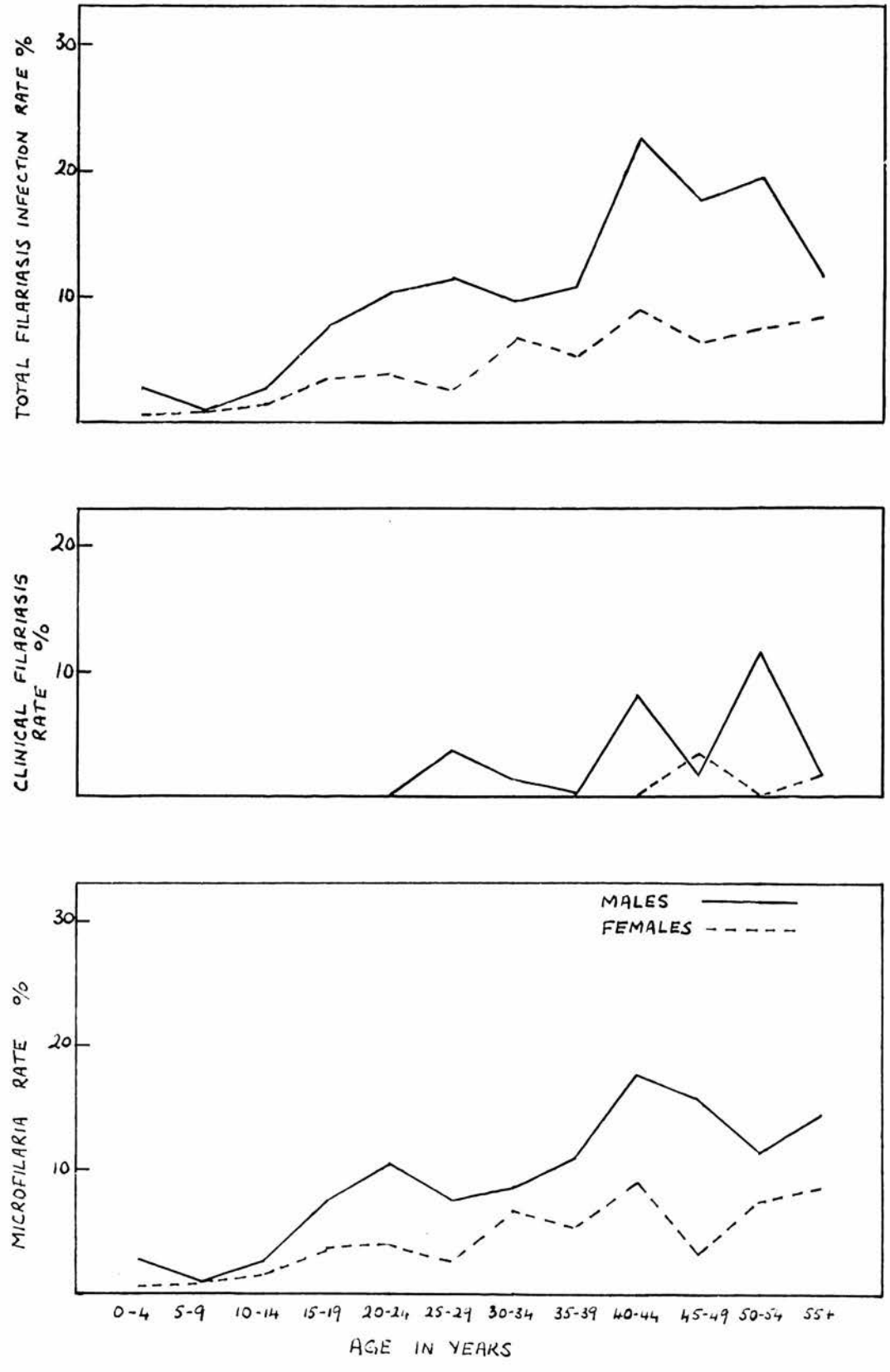
### 4.2.2. The effect of age and sex on the microfilaria and clinical filariasis rates.

Microfilaria and clinical filariasis rates by age and sex for the upper Kinabatangan and Tomani/Menggalong areas are presented in Table 11 and in graph 4. Figures obtained from the Benkoka area have been excluded for the reasons given in section 4.1.2. Microfilaria densities were very low (over 70% of films contained less than 6 microfilariae)

TABLE 11

Microfilaria and clinical filariasis rates by age and sex - W.bancrofti endemic area

| Age in years | Sex | No. examined | No.with microfilariae | No.with clinical filariasis | Microfilaria rate % | Clinical filariasis rate % |
|---|---|---|---|---|---|---|
| 0-4 | M | 266 | 7 | - | 2.6 | - |
| | F | 253 | 1 | - | 0.4 | - |
| 5-9 | M | 213 | 2 | - | 0.9 | - |
| | F | 201 | 2 | - | 1.0 | - |
| 10-13 | M | 150 | 4 | - | 2.7 | - |
| | F | 130 | 2 | - | 1.5 | - |
| 15-19 | M | 66 | 5 | - | 7.7 | - |
| | F | 89 | 3 | - | 3.4 | - |
| 20-24 | M | 59 | 6 | - | 10.2 | - |
| | F | 100 | 4 | - | 4.0 | - |
| 25-29 | M | 78 | 6 | 3 | 7.7 | 3.8 |
| | F | 108 | 3 | - | 2.8 | - |
| 30-34 | M | 81 | 7 | 1 | 8.6 | 1.2 |
| | F | 103 | 7 | - | 6.8 | - |
| 35-39 | M | 55 | 6 | - | 10.9 | - |
| | F | 57 | 3 | - | 5.3 | - |
| 40-44 | M | 62 | 11 | 5 | 17.7 | 8.1 |
| | F | 67 | 6 | - | 9.0 | - |
| 45-49 | M | 57 | 9 | 1 | 15.8 | 1.8 |
| | F | 32 | 1 | 1 | 3.1 | 3.1 |
| 50-54 | M | 36 | 4 | 4 | 11.1 | 11.1 |
| | F | 27 | 2 | - | 7.4 | - |
| 55 + | M | 56 | 8 | 1 | 14.3 | 1.8 |
| | F | 57 | 5 | 1 | 7.8 | 1.8 |
| TOTAL | M | 1178 | 75 | 15 | 6.4 | 1.3 |
| | F | 1224 | 39 | 2 | 3.2 | 0.2 |
| Both sexes | | 2402 | 114 | 17 | 4.7 | 0.7 |




Graph 4. Microfilaria and clinical filariasis rates by age and sex - W.bancrofti endemic areas.

and no useful comparison between densities in different age and sex groups could be made.

In males microfilaria rates rose until the 40–44 year age group and thereafter showed a very slight fall. In females the microfilaria rate rose gradually with age, but at a lower level than in males.

Clinical filariasis rates in males showed, overall, a rise with advancing age. Clinical lesions in females were not common.

## 5. Effect of treatment with diethylcarbamazine.

### 5.1. B.malayi

Seventy-one symptomless carriers of B.malayi were treated with diethylcarbamazine. Adults were given 100 mg. three times a day and children less than 12 years of age 50 mg. three times a day for 6 days. It was not possible to supervise the taking of each dose, and it may be that all the drug was not consumed. Twenty four of these people had night blood films examined after 3 days of treatment. Nine (37.5%) still had microfilariae in their blood, though in reduced numbers.

Nine of those treated were seen after 6 days treatment: one (11.1%) had microfilariae in his blood. These 9 were seen again 20 days after completing treatment: two (22.2%) had microfilaraemia.

### 5.2. W.bancrofti

Eleven symptomless carriers of W.bancrofti were treated with diethylcarbamazine, using the same dose as for B.malayi carriers. They were all seen 8 days after completion of treatment. One (9.1%) still had microfilariae in his blood.

5.3. Side effects of treatment.

All of the 71 B.malayi carriers treated were seen after 24-48 hours. Fifty one (74.1%) complained of fever and malaise, and 4 (5.6%) also complained of pain and tenderness in the inguinal region. Eighteen of those with fever were seen later after variable periods. They claimed to have continued treatment despire the fever, and said that after the fever had subsided (usually within 48 hours) further doses of the drug caused no further symptoms.

The 11 W.bancrofti carriers treated were seen 8 days after treatment. Seven (63.6%) claimed to have suffered fever and malaise during the first 48 hours of treatment.

6. The vectors

In all areas where mosquito catching was carried out, house spraying with insecticides had been done in connection with the malaria eradication programme, and this may have affected the results of the mosquito surveys.

In 1964/65, Dr. F.Y.Cheng, Malaria Eradication Programme Entomologist, Sabah, dissected mosquitoes caught in the Brunei Bay area; no filaria larvae were found.

The mosquitoes examined were:

| | |
|---|---|
| M.dives, M.bonneae, M.uniformis | 681 |
| Culex spp | 405 |
| A.donaldi | 220 |
| A.baezai | 51 |

In 1966/68 mosquitoes were caught by bare leg catching in areas where B.malayi and W.bancrofti were known to occur, dissected the following morning, and examined by the writer for filaria larvae.

Mosquitoes caught and dissected were :

| | |
|---|---|
| M.bonneae/dives | 1465 |
| M.uniformis | 141 |
| M.indiana | 62 |
| Culex spp. - unidentified | 1402 |
| A.leucosphyrus group | 4 |
| A.barbirostris group | 5 |
| A.sundacius | 2 |
| A.balabacensis | 11 |
| A.vagus | 151 |
| A.maculatus | 3 |
| A.kochi | 41 |
| A.donaldi | 19 |
| A.tessellatus | 1 |
| A.philippinensis | 1 |

Of 1,465 M.bonneae/dives examined, 3 (0.2%) contained infective larvae of Brugia species, and 9 (0.6%) contained developing larvae. Four contained unidentified infective larvae. No other mosquitoes examined were infected.

## 7. Animal hosts.

Thick blood films from a number of animals and birds from the Benkoka and Brunei Bay area were examined for microfilariae.

TABLE 12.

Animals and birds examined for microfilariae

| | No. examined | No. with Brugia spp. | No. with Dirofilaria | Unidentified microfilariae |
|---|---|---|---|---|
| Long tailed macacque (Macaca irus) | 8 | - | - | - |
| Pig tailed macacque (Macaca nemestrina) | 16 | - | - | 2 |
| Grey leaf monkey (Presbytis aygula) | 1 | - | - | - |
| Silver leaf monkey (Presbytis cristatus) | 4 | - | - | - |
| Malay Civet (Vivera tangalunga) | 16 | - | - | - |
| Squirrel (Calliosciurus spp.) | 9 | - | - | 1 |
| Giant squirrel (Ratufa affinis) | 1 | - | - | - |
| Common Palm civet (Paradoxurus hermaphroditus) | 1 | - | - | - |
| Flying fox (Pteropus vampyrus) | 1 | - | - | - |
| Cat (Felis domestica) | 20 | 2 | - | - |
| Dog (Canis familiaris) | 5 | - | 3 | - |
| Mouse deer (Tragulus javanicus) | 15 | - | - | 2 |
| Cow | 2 | - | - | - |
| Water buffalo (Bubalus bubalis) | 2 | - | - | - |
| Goat | 3 | - | - | - |
| Green pigeon | 37 | - | - | 6 |
| Hen | 14 | - | - | 2 |
| Other birds | 7 | - | - | - |

Most of these animals were shot in the evening or at night, and the blood films made within a few minutes of death. The blood films from domestic animals were made from live animals in the evening. Animals examined are listed in Table 12.*

Microfilariae of Brugia species were found in 2 cats from the Brunei Bay area. These were thought to be either B.malayi or B.pahangi. Differentiation between these species by examining microfilariae is difficult. The films were sent to Dr. J.F.B.Edeson of the American University of Beirut who, on the basis of measurements, thought they were B.pahangi.

## 8. The fluorescent antibody test in filariasis+

During the course of the survey an attempt was made to assess the value of the fluorescent antibody test in the diagnosis of filariasis, and its use as an aid to survey work.

The fluorescent antibody test has been used in several worm infections, including schistosomiasis (Sadun et al, 1961), onchocerciasis (Lucas and Hoeppli, 1963) and trichiniasis (Sadun, 1963). It has also been used to demonstrate antibodies in the blood of rabbits artificially immunised with extract of Dirofilaria uniformis (Sadun, 1963).

---

*In 1969, blood films were obtained from 6 clawless otters (Aonyx (Amblonyx) cinerea) at Chester Zoo; these animals had come from Brunei. Of the six, 4 had microfilariae of Brugia species in their blood. These are thought to be B.pahangi.

+Funds were made available for this work by the Ministry of Overseas Development, London, under Scheme R1825.

A technique using minute quantities of blood dried on filter paper has been described for the fluorescent antibody test in schistosomiasis (Anderson et al, 1961). The degree of sensitivity and specificity was at least equivalent to that reported for the fluorescent antibody test using human sera. Storage of dried blood specimens for up to two weeks, and variations in temperature and humidity did not alter the results (Sadun et al, 1961).

## 8.1. Materials and methods

The test used was the indirect fluorescent antibody test using microfilariae killed with formalin as the antigen.

The antigen was prepared from the blood of human microfilaria carriers of B.malayi. About 10 cc. of blood was withdrawn by venepuncture, and the red cells were lysed by the addition of distilled water. The microfilariae were concentrated by centrifugation, and washed three times in saline buffered to pH 7.2 (PBS). Most of the microfilariae were still alive after this procedure. They were then killed by the addition of 2.5% formalin, and washed again three times in PBS. Films of the microfilariae were then made on microscope slides, and allowed to dry.

Small quantities of blood were collected by finger prick from known carriers of microfilariae of B.malayi, or patients with elephantiasis, and dried on filter paper. Just before the test was performed, the serum was extracted by the method described by Anderson et al (1961) in which the blood containing filter paper is placed on a plastic tube, PBS added, and the serum forced from the tube by squeezing in a vice. The drop of fluid thus obtained was used as the test serum.

The test was performed by adding a drop of this test serum to the slide antigen and allowing it to act for one hour at room temperature (about 90°F). The slide was then washed in PBS for 15 minutes, with three changes of PBS. Fluorescein labelled anti-human globulin (Burroughs Wellcome) was then placed on the slide and allowed to act for one hour, after which the slide was washed with three changes of PBS and mounted in 90% glycerol under a cover slip. The preparation was examined with a fluorescent microscope, using a mercury vapour light source, bright field condenser and appropriate filters.

### 8.2. Results

Serum from 157 symptomless carriers of B.malayi was examined. Faint fluorescence was seen in two.

Serum from 4 patients with elephantiasis was tested; all showed bright fluorescence.

## 9. Discussion

During the investigation carried out in 1966-68, blood films from nearly 29,000 people were examined for microfilariae, and infections due to B.malayi and W.bancrofti were found. Filariasis in Sabah is a disease of rural areas, and infections were not found in towns or townships. About 9% of the population live in areas where filariasis is endemic. B.malayi and W.bancrofti were found in different topographical areas.

### 9.1. B.malayi

#### 9.1.1. Distribution and vectors.

The only form of B.malayi found was the subperiodic, and, as in Malaya and the Philippines, the distribution corresponded with the distribution of fresh water swamp forest. The vector was thought to be M.bonneae/dives. M.bonneae is the vector in Palawan in the Philippines, and in Malaya, where other species of Mansonia also transmit the disease. Only a relatively small number of mosquitoes were examined in Sabah, and it may be that had a more extensive search been made other species of Mansonia would have been found acting as vectors.

Open swamps with patches of water hyacinth, similar to the area of N.E.Malaya, where the periodic form of B.malayi occurs, are common on the west coast of Sabah. Little is known of the culicine mosquito population of these areas, but it seems likely that species of mosquitoes which in Malaya transmit periodic B.malayi are present. A.donaldi is commonly found in the West Coast, and in neighbouring Sarawak M.annulifera has been reported to be abundant in places (Macdonald et al, 1965). Despite the probable presence of suitable vectors, the periodic form of B.malayi was not found in Sabah. It has not been reported from the Philippines.

Periodicity studies of B.malayi in other parts of Borneo are not available, and the vector is unknown. Zuluetta's observations on filariasis in Sarawak and Brunei (1957) are based on the study of daytime blood films, and it seems unlikely that the form of B.malayi found was strictly nocturnally periodic* In Indonesian Borneo Kariadi (1938)

---

*The writer was informed by a retired dresser, employed for many years in Sarawak, that he had observed that microfilariae were found in day as well as night blood films from microfilaria carriers in coastal areas of Sarawak. These infections were probably due to B.malayi. This observation was made in the 1920's - many years before the two forms of B.malayi were distinguished in Malaya.

reported finding filaria larvae in M.uniformis and M.annulifira. More recently Klokke (1961) found infective filaria larvae in M.ochracea, M.longipalpis (=dives/bonneae) and M.annulata in a swamp forest area of S.E.Borneo where B.malayi was endemic. The species of these larvae is not known, nor their origin. If the vectors of B.malayi in Indonesian Borneo are the same as elsewhere, the entomological data available suggests that both forms of B.malayi may occur.

### 9.1.2. Susceptibility to infection

There is no evidence that susceptibility to infection is influenced by race. Most of those living in endemic areas in Sabah ar Kadazans and Brunei Malays, amongst whom the highest prevalence was found, but infections were also found among the few Chinese living in these areas. The absence of any racial factor in susceptibility to infection has also been noted in Malaya (Wilson, 1961).

### 9.1.3. Clinical manifestations

The clinical manifestations of infection with B.malayi were similar to those reported from Malaya - intermittent episodes of fever and lymphangitis, later associated with transient swellings of the affected limbs, eventually progressing to permanent elephantiasis. As in Malaya, elephantiasis most commonly affected the leg below the knee. The only lesion mentioned in Klokke's report from Indonesian Borneo (1961) is elephantiasis of the legs.

### 9.1.4. The effect of age and sex on elephantiasis and microfilaria rates, and on microfilaria densities.

Microfilaria and elephantiasis rates, and microfilaria densities, were influenced by age and sex. Elephantiasis was found to be commoner in men than in women, and in both there was an increase in elephantiasis rate with advancing age. The youngest male seen with elephantiasis was aged 18 years and the youngest female 22 years. In Malaya the incidence of elephantiasis follows a similar pattern, though elephantiasis rates are higher, and elephantiasis is observed in younger people. This may be associated with the higher level of transmission in Malaya.

Microfilaria rates differed little between the sexes until the 20–24 year age group. Thereafter microfilaria rates in males continued to rise, and in females to fall until the 35–39 year age group. Thereafter there was a fall in microfilaria rates in males with a rise in those over 55 years, and in females a steady rise. The pattern reported from Pahang in Malaya, where subperiodic B.malayi is endemic, is similar, though the difference in microfilaria rates is more marked and starts at an earlier age group – after 5–9 years. (Wilson, 1961). This difference in degree may be associated with the higher level of transmission in Pahang. A similar difference in prevalence in the two sexes was observed in Palawan (Cabrera and Tamondong, 1966), though in this area maximum microfilaria rates were reached early in life. In Indonesian Borneo, Klokke (1961) also reported that the incidence in males was higher than in females. The reason for this difference is unknown, but it may be associated with occupation and differences in exposure to infective bites by the two sexes, or other factors, perhaps hormonal, may be involved.

The changes in microfilaria rates in the different age/sex groups were preceded by changes in the same direction in the microfilaria densities. Microfilaria densities

in males increased till the 25-29 year age group and thereafter showed a steady decline. In females a maximum density was reached in the 5-9 year age group, after which the density declined till the 20-24 year age group, and thereafter rose slowly.

In Malaya, Wilson (1961) was able to show a similar difference between microfilaria densities in the two sexes in one area, but not in another. These microfilaria densities in Malaya were expressed as the mean microfilaria count per 20 cu.mm. of blood, and are not strictly comparable with the densities presented here.

From Palawan, Cabrera and Tamondong (1965) were unable to demonstrate any influence of age and sex on microfilaria densities: they too expressed densities as average microfilaria counts, and also grouped microfilaria counts as proportions within various limits. The numbers in each age/sex group were small.

## 9.2. W.bancrofti.

### 9.2.1. Distribution and vectors.

While the distribution of B.malayi corresponds closely with a particular type of terrain, no such close relationship was observed with W.bancrofti. Certain features however are common to all areas where W.bancrofti was found. All are hilly areas, with much primary forest, and the people spend much time in the forest. There are however many similar areas in the interior where filariasis was not found. Rainfall may be an important factor in maintaining suitable vectors in sufficient numbers to carry on transmission and it may be significant that the north east and south west are

the areas of maximum rainfall in the country. No reliable information about rainfall is available for the upper Kinabatangan region, but as flooding of the Kinabatangan river is common it may be supposed that rainfall in the area is high. Flooding is not commonly reported on the Sugut and Labuk rivers, or the Sembakong river (draining the Pensiangan area) and this may imply a lower rainfall in these areas.

The vector of W.bancrofti in Sabah was not identified. The malaria eradication staff report that filaria larvae have been found in A.balabacensis, the main vector of malaria in the interior of Sabah. However, most of the mosquito catching stations are in areas where W.bancrofti does not occur, and most of the dissections were carried out by technicians unfamiliar with filariasis: the larvae reported to have been found may not have been filaria larvae*, or if they were, may have been of bird or animal origin.

In neighbouring Sarawak, Zuluetta (1957) reported finding filaria larvae (unidentified and of unknown origin) in A.leucosphyrus and A.barbirostris caught in areas where W.bancrofti occurs. Though these larvae may not have been of human origin, they were the only larvae found in the course of examining large numbers of mosquitoes, and A.leucosphyrus and A.barbirostris may be the vectors of W.bancrofti.

In Malaya and the Philippines several species of Anopheles and one species of Aedes have been found to be vectors of W.bancrofti. It seems likely that the vector in Sabah is a jungle dwelling Anopheles or Aedes. Clearly more work on this aspect of

---

*During mosquito dissections in 1966/68, worms, thought to be of the family Mermithidae, were found in some areas in the abdomens of C.fatigans: such infections might be confused with filarial infections.

the epidemiology of filariasis is required.

W.bancrofti in Sabah appears to be nocturnally periodic, as it is in Malaya (Wharton et al, 1963) and the Philippines (Cabrera and Rozeboom, 1965), though in the Philippines occasionally an infection may be found that is more characteristic of the subperiodic than the periodic form. In many parts of south east Asia W.bancrofti is an urban disease transmitted by C.p.fatigans, and the finding in recent years of foci of infection with the parasite in remote rural areas has caused speculation about the origins and spread of the disease. It may be that these urban, Culex-transmitted strains of W.bancrofti were introduced into rural areas by Indian and Chinese traders, and became adapted to other vectors, but there is a growing body of opinion that this is unlikely to have taken place (Zuluetta, 1957; Wharton, 1960; Rozeboom and Cabrera, 1966), and it seems more likely that the disease was originally a rural infection transmitted by Anopheles and perhaps also rural culicines, and has subsequently become adapted to C.fatigans (Laurence and Pester, 1967).

In Sabah, the finding of W.bancrofti in the interior, where contact with other groups even now is infrequent, lends support to the view that the parasite is probably indigenous.

### 9.2.2. Clinical manifestations

As has been pointed out by Edeson and Wilson (1964) in different areas of the world there is considerable variation in the incidence of disease and the type of lesion produced by infection with W.bancrofti. In East and West Africa there is a large proportion of hydroceles, and elephantiasis of the legs is less common. (Jordan, 1955;

Hawking, 1957). In India, elephantiasis of the legs is common, and hydrocele less so (Raghavan, 1957). In China the main lesions are hydrocele, chyluria and elephantiasis of the scrotum and limbs (Li Huei-Han; 1959).

In the Philippines, Estrada and Basio (1965) reported that 94.1% of those with elephantiasis had scrotal elephantiasis and 3% elephantiasis of the lower limbs. Chyluria and elephantiasis of the breast was also seen. The distinction between elephantiasis of the scrotum and hydrocele is not made clear. 65% of those reported to have elephantiasis had microfilariae in their blood.

The rural foci of W.bancrofti in Malaya have not been fully investigated and no reports of the clinical manifestation of infection are available.

In Sabah, of those with clinical manifestation of disease in endemic areas of W.bancrofti, 65% had hydrocele and 35% elephantiasis of both legs. 27% of those with hydrocele had microfilariae in their blood. None of those with elephantiasis of the legs had microfilaraemia.

In the only area where W.bancrofti infections were endemic, where it is thought that reliable information about clinical manifestations was obtained, a higher proportion of those infected had clinical disease than in areas where B.malayi was endemic.

Examples of ratios of symptomless microfilaria carriers to those with clinical disease are given in Table 13.

TABLE 13

Ratio of symptomless microfilaria carriers to those with clinical disease

| B.malayi endemic areas | Ratio | W.bancrofti endemic areas | Ratio |
|---|---|---|---|
| Brunei Bay | 10 : 1 | Upper Menggalong | 3 : 1 |
| Sugut/Labuk/ Kinabatangan | 14 : 1 | Tomani area | 2 : 1 |

9.3. Effect of treatment with diethylcarbamazine.

It was not possible to supervise the treatment of the patients with filariasis who were given diethylcarbamazine. Nevertheless treatment did reduce considerably the number of microfilaria carriers of both W.bancrofti and B.malayi, at least for the brief period during which the effects of treatment were observed.

Side effects of treatment were reported in about 75% of the B.malayi and about 65% of the W.bancrofti carriers, and these side effects were usually sufficient to prevent the person affected from continuing his usual work.

Treatment of B.malayi carriers in Malaya with diethylcarbamazine also produced a higher incidence of side reactions than treatment of W.bancrofti carriers reported from elsewhere (Wilson, 1950). The high incidence of unpleasant side effects of treatment clearly increases the difficulties of securing co-operation in attempting control measures by mass drug administration.

9.4. Animal infections.

The number of animals examined in Sabah was small. In country covered with thick jungle wild animals are difficult to catch or shoot. Domestic animals presented their

own problem. House spraying with insecticides has caused the death of many cats, especially in rural areas, and there is a shortage of these animals. Most of those examined were very young. In many areas dogs are highly prized and are trained to help in hunting wild animals. Trained dogs change hands for very large sums of money, and their owners were reluctant to have them examined. As the presence or absence of an animal reservoir of infection is important in the epidemiology of filariasis, clearly a more intensive search for such a reservoir should be carried out, in both W.bancrofti and B.malayi endemic areas.

## 9.5. The fluorescent antibody test.

The fluorescent antibody test was carried out on 157 symptomless carriers of B.malayi and 4 patients with elephantiasis. In 2 of the symptomless carriers faint fluorescence was seen, but this was considered too faint to be recorded as positive. By contrast the serum from patients with elephantiasis showed bright fluorescence.

During similar work carried out in Malaya, it was not possible to demonstrate fluorescent antibodies in symptomless microfilaria carriers, but antibodies were found to be present in all those examined who had elephantiasis (Wong, personal communication).

Jayewardine and Wijayaratnam (1968) reported that they were unable to demonstrate antibodies in symptomless carriers of W.bancrofti, but were able to do so in a proportion of those with clinically active disease.

The work in Sabah confirms these findings. While the fluorescent antibody test appears to be of some use in the diagnosis of filariasis in those who have already developed symptoms, it is of no value in detecting symptomless microfilaria carriers. It is unlikely to have any value as an aid to filariasis survey work.

## 9.6. The future

Though about 9% of the population of Sabah lives in areas where filariasis is endemic, in general microfilaria and elephantiasis rates are low, and the disease is not at present a major public health problem. However, land development, resettlement schemes, de-forestation, etc., are altering the ecology of the countryside in many places, and it is difficult to forecast what effect this will have on the transmission of filariasis. In many parts of the world the prevalence of filariasis is increasing largely due to urbanisation. In Sabah the likelihood is that land development will reduce the amount of contact between man and the vectors of filariasis, but it may be that both W.bancrofti and B.malayi will become adapted to other vectors. Filariasis surveys should be repeated from time to time, both in known endemic areas, and in areas being resettled, and in urban areas.

In most of the areas where filariasis is endemic, house spraying with insecticides has been carried out for several years, and the finding of infection with both B.malayi and W.bancrofti in children born since the spraying commenced suggests that application of residual insecticides is unlikely to interrupt the transmission of filariasis. Control measures, if undertaken, will probably rely on the mass administration of diethylcarbamazine. If this is pursued with vigour, and if care is taken to explain to the people about the side effects, and to deal with these effects, a considerable reduction in the prevalence of the disease should be possible.

Further work should be undertaken to establish the vectors of W.bancrofti and the presence or absence of animal reservoirs of infection with both B.malayi and W.bancrofti.

# REFERENCES


Anderson, R.I., Saduo, E.H. and Williams, J.S. (1961). A technique for the use of minute amounts of dried blood in the fluorescent antibody test for schistosomiasis. Expl Parasit., 11, 111.

Barclay, R. (1965). Filariasis in south-west Sabah. Ann.trop.Med.Parasit., 59, 340.

Brug, S.L. (1920). Filariasis in Nederlandsch - Indie. Geneesk.Tijdschr.Ned. - Indie. 60, 601.

_____ (1931). Filariasis in Nederlandsch - Indie, III. Geneesk.Tijdschr.Ned - Indie. 71, 210.

Cabrera, B.D. (1960). Determination of mosquito vector of filariasis in Southern Sulu. J.Philipp.med.Ass., 44, 117.

_____and Rozeboom, L.E. (1965). The periodicity characteristics of the filaria parasites of man in the Republic of the Philippines. Am.J.Epidem., 81, 192.

_____and Tamandong, C.T. (1966). Bancroftian and Malayan filariasis in Palawan. Extent and distribution. Acta med.Philipp., 2, 20.

_____ (1966). Filariasis survey in Jolo, Sulu. Acta med. Philipp., 2, 86.

_____and Tubangui, M. (1951). Studies on filariasis in the Philippines. III: Aedes (Finlaya) poicilius (Theobald), the mosquito intermediate host of Wuchereria bancrofti in the Bicol region. Acta med.Philipp., 7, 221.

Cheong, W.H. and Abu Hassan bin Omar, (1965). Anopheles maculatus, a new vector of Wuchereria bancrofti in Malaysia (Pulau Aur) and a potential vector on mainland Malaya. Med.J.Malaya, XX, 74.

Clarke, M.C. (1951). Some impressions of the Muruts of North Borneo. Trans.R.Soc. trop.Med.Hyg., 44, 453.

Danaraj, T.J., Schacher, J.F., and Colless, D.H. (1958). Filariasis in Singapore. Med.J.Malaya, 12, 605.

David, H.L., and Edeson, J.F.B. (1965). Filariasis in Portuguese Timor, with observations on a new microfilaria found in man. Ann.trop.Med.Parasit., 59, 193.

Edeson, J.F.B., and Wharton, R.H. (1958). The experimental transmission of Wuchereria malayi from man to various animals in Malaya. Trans.R.Soc. trop.Med.Hyg., 52, 25.

_____, Wilson, T., Wharton, R.H., and Laing, A.B.G. (1960). Experimental transmission of Brugia malayi and B.pahangi to man. Trans.R.Soc.trop.Med. Hyg., 54, 229.

_____(1964). The epidemiology of filariasis due to Wuchereria bancrofti and Brugia malayi. A.Rev.Ent., 9, 245.

Estrada, J.P., and Basio, D.G. (1965). Filariasis in the Philippines. J.Philipp.med. Ass., 41, 100.

Hawking, F. (1957). The distribution of bancroftian filariasis in Africa. Bull.Wld Hlth Org., 16, 581.

Jayewardine, L.G., and Wijayaratnam, Y. (1968). The fluorescent antibody test in the serological diagnosis of the causative organisms of tropical eosinophilia and filariasis. J.Helminth., XLII, 57.

Jordan, P. (1955). Observations on Wuchereria bancrofti and Acanthocheilonema perstans in Tanganyika. Trans.R.Soc.trop.Med.Hyg., 49, 460.

Kariadi, M. (1938). Crienteerend filariaonderzoek te Martapoera (Res.Z/O Afa v.Borneo). Geneesk.Tijdschr.Ned.- Indie, 78, 1127.

Klokke, A.H. (1961). Filariasis due to Brugia malayi in South Borneo (Indonesia). Trans.R.Soc.trop.Med.Hyg., 55, 433.

Laing, A.B.G., Edeson, J.F.B., and Wharton, R.H. (1961). Studies on filariasis in Malaya; further experiments on the transmission of Brugia malayi and Wuchereria bancrofti. Ann.trop.Med.Parasit., 55, 86.

Laurence, B.R., and Pester, F.R.N. (1967). Adaptation of a filariae worm, Brugia patei, to a new mosquito host, Aedes togoi. J.Helminth., 41, 365.

Li Huei - Han (1959). Studies on filariasis in New China. Chinese Med.J., 78, 148.

Lucasse, C., and Hoeppli, R. (1963). Immuno fluorescence in onchocerciasis. Z.Tropenmed.Parasit., 14, 262.

Macdonald, W.W., Smith, C.E.G., and Webb, H.E. (1963). Arbovirus infections in Sarawak : observation on the mosquitoes. J.med.Ent., 1, 335.

Raghavan, N.G.S. (1957). Epidemiology of filariasis in India. Bull.Wld Hlth Org., 16, 553.

Register, P.T. (1956). The study of primitive communities and its relation to social medicine, with particular reference to the Muruts and Dusuns of North Borneo. J.Roy.Inst.publ. Hlth Hyg., 19, 350.

Reid, J.A. (1963). Notes on anopheline mosquitoes from Malaya, with descriptions of three new species. Ann.trop.Med.Parasit., 57, 97.

Rozeboom, L.E., and Cabrera, B.D. (1965). Filariasis caused by Brugia malayi in the Republic of the Philippines. Am.J.Epidem., 81, 200.

_____ (1965). Filariasis caused by Wuchereria bancrofti in Palawan, Republic of the Philippines. Am.J.Epidem., 81, 216.

_____ (1966). Filariasis in the Republic of the Philippines: epidemiology and possible origins. Acta Med.Philipp., 3, 112.

Sadun, E.H.(1963). Seminar on immunity to parasitic helminths. VII. Fluorescent antibody technique for helminth infections. Expl Parasit., 13, 76.

_____, Anderson, R.I. and Williams, J.S. (1961). Fluorescent antibody test for the laboratory diagnosis of schistosomiasis in humans, using dried blood smears on filter paper. Expl Parasit., 11, 117.

Shircore, J.O. (1937). Report on native health. North Borneo Company.

Turner, L.H. (1959). Studies on filariasis in Malaya: the clinical features of filariasis due to Wuchereria malayi. Trans.R.Soc.trop.Med.Hyg., 53, 154.

Wharton, R.H. (1960). Studies on filariasis in Malaya: field and laboratory investigations of the vectors of a rural strain of Wuchereria bancrofti. Ann.trop.Med. Parasit., 54, 78.

_____ (1962). The biology of Mansonia mosquitoes in relation to the transmission of filariasis in Malaya. Bull.Inst. med.Res.Malaya, No.11.

Wharton, R.H., Laing, A.B.G., and Cheong, W.H. (1963). Studies on the distribution and transmission of malaria and filariasis among aborigines in Malaya. Ann.trop.Med.Parasit., 57, 235.

Wilson, T. (1950). Hetrazan in the treatment of filariasis due to Wuchereria malayi. Trans.R.Soc.trop.Med.Hyg., 44, 49.

_____ (1954). Annual Report of the Institute for Medical Research, Malaya, 1953, p.73.

_____ (1956). Differences between the microfilariae of Wuchereria malayi and W.bancrofti in Giemsa-stained thick blood films. Trans.R.Soc.trop.Med. Hyg., 50, 54.

_____ (1961). Filariasis in Malaya - a general review. Trans.R.Soc.trop.Med. Hyg., 55, 107.

_____, Edeson, J.F.B., Wharton, R.H., Reid, J.A., Turner, L.H. and Laing, A.B.G. (1958). The occurrence of two forms of Wuchereria malayi in man. [Correspondence.] Trans.R.Soc.trop.Med.Hyg., 52, 480.

World Health Organization (1967). Expert Committee on filariasis (Wuchereria and Brugia infections). Wld Hlth Org.Tech.Rep.Ser., No. 359.

Zuluetta, J. de (1957). Observations on filariasis in Sarawak and Brunei. Bull.Wld Hlth Org., 16, 699.